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The Influence of Mechanical Guidance Upon Maze Learning

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I

INTRODUCTION

The general purport of this study is an investigation of the influence upon maze learning of the mechanical prevention of error.

The research was carried on in the years 1919-1920 at the Psychological Laboratory of the University of Chicago and was a direct outgrowth of an investigation conducted jointly by Dr. H. A. Carr and the author,[1] in which an attempt was made to train some albino rats to do a task by guiding them for a time through the critical phase of the situation. The guidance was mechanical in its nature, and, while conducting the animal through the proper response, it still permitted him to initiate all of his activities. The problem to be mastered was the alternate choice of the right and left paths of a T-shaped problem box in each day's test of ten successive runs. The results revealed that the group of animals which was guided forty out of every fifty trials did not react to the situation so effectively as did the unguided group. The control was not, however, without marked positive effect upon some of the animals.

The maze problem was selected as the medium for the present investigation for the following reasons: (1) In so far as the maze differs from the problem box just described, its employment will cast some light upon the question of the relation between the nature of the problem and the effectiveness of control. (2) The maze problem is an eliminative type of problem; that is, its mastery involves primarily the elimination of error, rather than the acquisition of any new movement. It is reasonable to expect that control which consists of the prevention of errors will have a greater influence upon the learning of such a problem than upon the learning of those in whose mastery sheer elimination of errors plays a less dominant rôle. (3) The character of the problem is such, furthermore, that it permits a more detailed analysis of the learning process and of the nature of the effect of the control than

[1] "The Influence of Extraneous Controls in the Learning Process," *Psych. Rev.*, vol. 26 (1919), p. 287 ff.

does the problem box hitherto employed. (4) The maze presents a problem which is well adapted to the capacities of both human subjects and rats, and thus makes possible a comparative study of the influence of control upon these widely divergent animal groups.

Our general method of procedure consisted in preventing cul-de-sac errors in certain periods of the learning, by blocking the entrances to the blind alleys. The guiding device was mechanical and, hence, subject to little variation. The subject, moreover, was permitted to initiate all of his movements. In this respect our method of control diverges from that method frequently employed, in which the subject, who is supposedly passive, is guided by the experimenter through the movements of the act to be learned. The influence of this form of control has been investigated by Thorndike,[2] Cole,[3] Yerkes,[4] Hunter[5] and Ludgate.[6]

The problems upon which the present study will attempt to cast light are the following: (1) Does the mechanical prevention of errors during part of the learning process have any influence upon learning? (2) Does the efficacy of the control vary with the period of the learning at which it is administered? A comparison, for instance, of the relative effectiveness of guidance given in the initial four trials, as opposed to control given in the trials from the ninth to the twelfth inclusive, will furnish significant data in regard to this problem. (3) Is the efficacy of guidance a function of the amount given? Our general method of investigating this problem is to consider, for example, the relative effectiveness of two, four or six, etc., directed trials, interpolated in the same general position in the learning process. (4) Does guidance have a similar influence upon human and animal subjects? (5) Does the fact of guidance in the learning period have any influence upon

[2] "Animal Intelligence," *Psych. Rev. Mon. Suppl.*, vol. 2 (1898).

[3] "Concerning the Intelligence of Raccoons," *Jour. of Comp. Neur. and Psych.*, vol. 17 (1907), p. 211 ff.

[4] "The Dancing Mouse," (1907), p. 201 ff.

[5] "A Note on the Behaviour of the White Rat," *Jour. of Animal Behav.*, vol. 2 (1912), p. 137 ff.

[6] "The Effect of Manual Guidance upon Maze Learning," *Psych. Rev. Mon. Suppl.*, vol. 33 (1923).

the retention of the habit? To state the problem more simply: Does a subject who has been guided during the learning of a problem retain the habit as well as the subject who has not been so guided? (6) Does the fact of guidance in the learning period affect the stability of the habit? In other words, is an individual who has mastered the problem with the aid of guidance as likely to be confused when circumstances are slightly altered as is the individual who has learned the problem without extraneous control?

The maze used in the experimentation upon the animals was constructed of oak boards, ½″ in thickness. It was supported by a wooden frame 18″ high and was 4′x3′8″x6″ in size. The pattern of the maze is indicated in Fig. 1. The runways and the cul-de-sacs

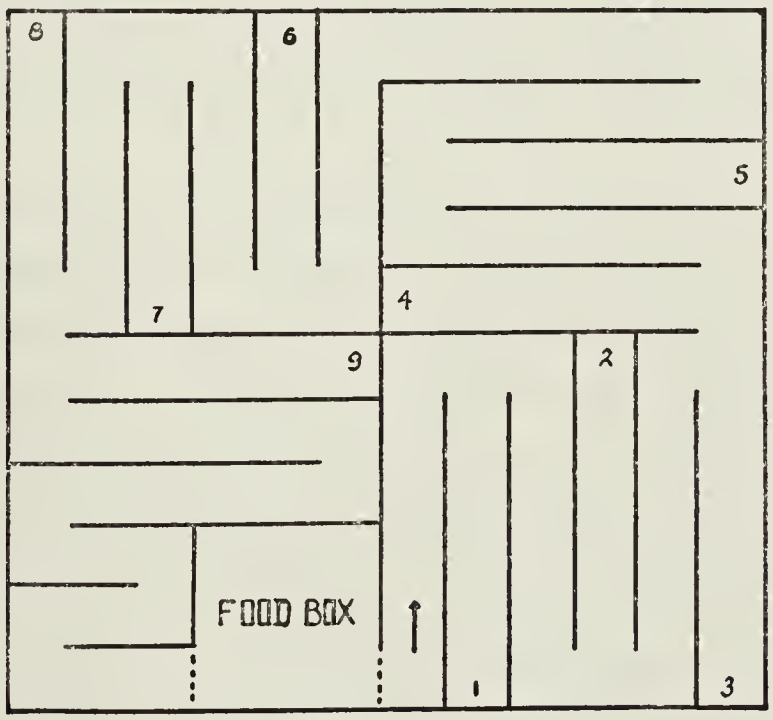

FIG. 1

were 4″ wide. The partitions within the maze, which were made of thin sheets of galvanized iron, were held in place by brass supports. The wood and metal parts of the apparatus were painted dull black. A glass cover permitted observation of all of the maneuverings of the animal while he was in the runways. The doors that opened into and out of the uncovered food-box were sliding doors which, with a little care, could be closed without distracting the animal to any considerable degree.

The blind alleys were closed off, when desired, by pieces of

window glass. Attached to the upper edge of each plate of glass was a blackened brass clamp which, when sunk into the sockets in the walls of the alleys, held the glass partition securely in place. The glass controls were not set in flush with the walls of the main pathway, but rather at a distance of three centimeters from the ends of the cul-de-sacs. This arrangement was adopted in order to avoid, as far as possible, the distraction from the alteration of tactual cues which one would expect to attend the introduction and removal of the controls. Glass, moreover, rather than metal partitions, were employed, in order to reduce to a minimum the visual distraction, which the introduction and abstraction of the control might produce.

After some preliminary experimentation, the results of which indicated that directed trials occurring subsequent to the twelfth have a marked deleterious effect, it was decided to concentrate within the first twelve trials whatever guidance was given the animals.

Series of two, four, six or eight guided trials were, with one exception, inserted in various positions within the first twelve trials involved in the learning of the maze. A series of two successive guided trials was introduced, in the case of one group of animals, upon the first run; in the case of another, upon the sixth run; and for a third group, upon the eleventh run. Four groups of animals were granted a period of control, extending over four successive trials. The period of guidance began with the first, fifth, ninth or thirteenth trial, respectively. Series of six directed trials were employed, in the case of three groups of animals, the introduction of the directed series occurring upon the first, fourth or seventh trial, respectively. Successions of eight guided trials, commencing upon the first, third or fifth run of the learning period, respectively, were likewise employed. One group of animals was given twelve successive directed trials. The normal group, of course, learned the maze without assistance. It is evident from the schema just described that each group of animals received either two, four, six or eight guided runs at either the beginning, middle or end of the first twelve trials. Such a grouping enables one to compare the relative effect of various amounts of guidance, as

well as the effect of the position of the guided trials upon learning.

Sixteen groups of ten animals each were employed in the course of the experiment, each group consisting, because of the scarcity of females, of six males and four females. The rats were from seven to twelve weeks old. Any marked biasing of the results, through differences in the strain of the animals used, was avoided by drawing each group from no less than three different litters.

The rats were carefully tamed and fed in the food-box of the maze for one week before training was begun. Whatever physical mutilation of the animal was necessary for purposes of identification was effected at least three days before training commenced. The position of the maze was never changed during the learning period of any group of animals. Lighting conditions were controlled as far as possible. The shades were drawn and the electric light switched on before work was begun. The experiment was conducted in the late morning and early afternoon hours. The cleaning of the cages and replenishing of the water supply, etc., was cared for after the day's trials. Thus, for the accomplishment of any necessary adjustments to the slight alterations in the environment, a period of twenty-four hours was allowed. The same general position of the living cage of any group of animals was maintained throughout the entire experiment.

The animals were kept normally hungry. They were allowed to feed seven minutes per day on bread and milk, were fed on an average six sunflower seeds per individual per day, and once a week were favored with a small piece of lettuce or apple. One bite of food before each run served to stimulate the proper incentive. The animals of each group were fed together at the end of the daily experimentation.

During the first four days, each rat was granted only one trial per day. Thereafter, however, it was given two trials per day until it succeeded in making four perfect runs out of five successive attempts. This criterion of mastery has previously been successfully employed.[7] No record of the distance traversed was

[7] *Cf.* Webb: "Transfer of Training and Retroaction," *Psych. Rev. Mon. Suppl.*, vol. 24 (1917).

kept, as Miss Hicks[8] suggests; but the method of counting errors obviated to a large degree many of the difficulties she discusses. Any return over a whole or a part of a unit of the true pathway was counted as a return error. A unit of the true pathway, to be explicit, consists of a section of the runway between two successive turns of the true path, irrespective of the length of the section. Every entrance into a cul-de-sac, as well as every retracing toward the end of the cul-de-sac, after the animal had headed toward the entrance, was considered a cul-de-sac error.

Time, measured by a stop watch, was recorded from the moment the rat left the entrance until its whole body, with the exception of its tail, was brought within the food-box.

The maze employed in the experiment upon human subjects was a small stylus maze of the same general design as the maze used for the rats. The cul-de-sacs and the true pathway, which were milled out of a solid aluminum casting, were ¼″ wide and ¼″ deep. The partitions between these wedges were, likewise, ¼″ thick. The outside dimensions of the maze were 5¾″ x 5¼″. Small brass blocks, from the bottom of which projected pegs that could be inserted into small holes drilled into the floor of the maze, were used to block off the blind alleys in the directed trials. The blocks were inserted at the same relative distance from the end of the cul-de-sacs as were the glass controls in the maze used in the experimentation upon animals. The absolute distance was $^{3}/_{16}''$.

The maze was concealed under a heavy black curtain that covered the top and three sides of a supporting wooden frame. The frame was 1½ ft. wide, 1 ft. deep, and 1 ft. high on the side toward the subject, whereas it was 1½ ft. high on the side exposed to the experimenter. From that side of the frame which was uncovered, the experimenter could observe the progress of the subject. In order to prevent any distracting movement, the maze was held tightly in place by a small wooden frame which was nailed to the table. The black cloth was hung loosely enough on the side toward the subject so that his arms could be easily in-

[8] "The Relative Value of the Different Curves of Learning," *Jour. of Animal Behav.*, vol. I, (1911), p. 138 ff.

serted under it. Such an apparatus eliminates the disconcerting effect of blindfolding and reduces the problem largely to a tactual kinaesthetic-motor level.

The subjects were required to trace the maze with a hard rubber stylus, the lower end of which was $^{3}/_{16}''$ in diameter and could be guided easily through the runways. A small rubber shield $^{5}/_{16}''$ from the end of the stylus prevented the fingers of the subject from coming in contact with the maze. For both human and animal subjects the same criterion of mastery was employed.

The subject was seated at a table and the following written directions were given to him: "Please put your right hand under the cover. Grasp the stylus and hold it as erect as possible. Be sure that neither your fingers nor your hand touches the base of the apparatus. Keep the stylus in the groove and explore the assigned area until you are told to stop. Use any method you desire. The aim of the experiment is to find the shortest possible route through the maze." When the subject placed his hand under the cover, the experimenter put the stylus in it and placed the stylus in the groove at the entrance to the maze. Then the experimenter said to the subject, "Now you are in the groove. Explore the maze and I shall tell you when you reach the goal." When the subject reached the goal for the first time, the experimenter said to him, "Now you have reached the goal. The aim of the experiment is to learn to reach this goal without taking any unnecessary steps." The object of giving instructions to the subject thus piecemeal is to avoid confusing him with a large number of directions, the meaning of which can only become apparent when he has had some experience with the situation. The repetition in various forms of the aim of the experiment is necessary in order that each subject may thoroughly comprehend what is desired of him. Such a procedure as Webb's,[9] in which the subject was forced to deduce the aim of the experiment, is wholly undesirable. Webb asserts that because the human subject is blindfolded and is obliged to fathom the desires of the experimenter, his incentive is similar to that of the rat who is placed in the maze and allowed to seek his own deliverance. Upon a close scrutiny of the situation and the behavior of the sub-

[9] *Op. cit.*, p. 14.

jects, the similarity is not so evident. The human subject does, from the first, set for himself a problem. The problem, if the subject is not instructed, differs with each individual. Some subjects believe that the problem is to traverse every inch of the maze, rather than to find the shortest route. The rat, we assume, moves through the maze at first through sheer curiosity and inability to be quiet unless fatigued, ill, asleep or in danger. After the first few trials, food and the maze situation become associated. Each rat, after the initial trials, has the same incentive. But the human subject has no such incentive and no criterion of success unless he is told what he is to do. While Webb's procedure does *a priori* keep the conditions for human and animal subjects strikingly similar, nevertheless, the action of the subjects indicates that the human with a knowledge of the problem has an incentive more nearly comparable to that of the rat than the subject without such information. A comparison of the records for a group of ten subjects who labored through the maze without a knowledge of what was desired of them, with an instructed group reveals that this information is effective in producing a drop in the trial score from 70.6 to 44.3; in the total error score from 476.1 to 325.1; and in the total time score from 2250.82″ to 1465.59″. Such results refute Webb's[10] assertion that knowledge of the aim in the maze problem has little effect on learning.

Because of the great difficulty of inducing a large number of rather disinterested subjects to serve regularly for any length of time, the same distribution of trials was not employed as in the case of the investigation with animals. The experiment was so arranged that the problem could usually be mastered at a single sitting. No subject was detained, however, for more than 1½ hours at a time. If the problem was not mastered within this period, the subject was requested to return every 48 hours until a mastery was effected. If a subject became fatigued, he was dismissed after one hour. Between the first and second trials, as well as between the second and third, a rest of one minute was granted. If the first trial required more than fifteen minutes, the subject was granted all the time he needed to recover from fatigue. After the second

[10] *Op. cit.*, p. 15.

trial a rest of one minute was given between groups of two trials. This distribution of effort in a large measure obviated fatigue, as well as the confusion which results from too steady application.

The subject was at no time informed that he was being guided. The insertion and extraction of the blocks were accomplished noiselessly.

The scheme for the introduction of the controlled trials was slightly varied from the one employed in the experimentation upon the animals, in order to bring out more clearly the effect upon learning of various amounts of guidance. Six groups of subjects were controlled for a period extending over two successive trials. The control, in the case of these groups, was introduced upon the first, third, fifth, seventh, ninth and eleventh trial, respectively. Three groups of subjects were each granted a period of guidance, four trials in length. The series of four controlled runs began, respectively, upon the first, fifth and ninth trial. Two groups were guided through a series of six successive trials, one of the groups being guided through the first six trials of the learning period; the other, from the seventh to twelfth trial, inclusive. Two groups of subjects, likewise, were given eight directed trials; one group being guided from the first to the eighth trial, inclusive; the other, from the ninth to the sixteenth. One group was guided through the initial twelve trials. The normal group learned the maze without assistance.

Each of the fifteen groups consisted of ten individuals—eight women and two men. All were students or instructors at the University of Chicago. Most of the subjects were naïve, so far as the maze situation was concerned. The few students who were familiar with the maze problem were equally distributed through all of the groups, in order to prevent a weighting of the results by this factor.

The retention and distraction tests were carried on 48 hours after the mastery of the problem had been effected. Retention was tested by a single tracing of the maze.

Each subject traced the maze under nine different distracting conditions. The distractions employed were a shifting of the position of the maze through 90°, 180° and 270°, respectively; the

silent recitation of the first stanza of "Mary had a little lamb"; reading aloud; drawing triangles with the left hand while the right traversed the maze, and *vice versa;* tracing the maze with the left hand; and traversing it from the so-called goal back to the entrance. When the maze was shifted 90° from its original position, as well as 180° and 270°, the subject was not informed of the nature of the change, nor was he told that he was being distracted in any way. This procedure of keeping the subject in ignorance of the altered environment until he discovered it for himself, was adopted in order that the conditions might more closely resemble those of general life in which changes in a situation are seldom discreetly labelled, but are rather left to the individual to decipher.

II

THE RELATIVE EFFICACY OF CONTROL INTRODUCED AT VARIOUS POSITIONS IN THE LEARNING PROCESS

It is of great practical value to know what is the most opportune time in the learning process for guiding or instructing an individual and to be cognizant of the effects of guidance at the various stages in the mastery of a problem. Toward the solution of this question the present study has taken only one small step. Our problem is a description and analysis of the relative efficacy of mechanical guidance introduced at various stages in the learning of a maze.

For purposes of analysis it is desirable to consider the influence of control from three points of view: namely, from the point of view of the result immediately manifested, the result subsequently exhibited, and the total result. The immediate influence of the control is that which is evident during the period in which guidance is being administered. The subsequent influence is that manifested in the undirected trials following the controlled series. The total effect is a composite of the two influences just described and will be represented by such measures as total time, total errors and total trials.

Before a discussion of the results is attempted, a comment on the method of deriving the scores is necessary. In order to gain the increased validity resulting from an increase in the number of cases, all available measures which bore on any point in question were employed. There were ten groups of rats, for example, which were unguided in the first two trials. Hence, since there were ten animals in each group, the normal score for these two runs is an average of one hundred measures. The scores for the eleventh and twelfth trials in the normal series, on the other hand, are based upon only twenty measures: *i.e.*, upon the records of the animals in the group which received no guidance and those

in the group guided from the thirteenth to the seventeenth trial. The other eight groups whose records were used in deriving the scores for the first and second trials had received some guidance before the eleventh run. Since a normal score for a given trial is an average of the scores for an unguided run, the total series of trials preceding which are also unguided, the records of these eight groups could not be employed in computing the scores for the eleventh and twelfth trials in the normal series.

The same principles of selection and elimination were utilized in deriving the scores for the directed trials. There were five groups which were guided during the first and second trials. Hence, the scores for the first two directed runs are based upon fifty measures. The scores for the third and fourth trials, when these runs are themselves controlled and preceded by directed trials only, are computed on the basis of forty measures. The record of that group receiving guidance in only two of the initial trials could not be employed in computing the scores for these trials, as it had been in deriving the scores of the first two directed runs. Hence, the reason for the reduction from fifty to forty measures is evident. The number of cases used in deriving any average is indicated in Table 1.

TABLE 1. NUMBER OF CASES USED IN COMPUTING A GIVEN SCORE—ANIMAL SUBJECTS[1]

Serial Number of the Trials for which an Average Score is Sought	Nature of the Trials		Number of Uncontrolled Trials Preceding Trials for which an Average Score is Sought	Number of Controlled Trials Preceding Trials for which an Average Score is Sought	Number of Cases upon which Average is Based
	Controlled	Uncontrolled			
1-2		x			100
3-4		x	2		80
1-4		x			80
5-6		x	4		40
1-6		x			40
7-8		x	6		30
1-8		x			30
9-10		x	8		20
1-10		x			20
11-12		x	10		20
1-12		x			20
1-2	x				50
3-4	x			2	40
1-4	x				40
5-6	x			4	30
1-6	x				30
7-8	x			6	20
1-8	x				20
5-6	x		4		20
7-8	x		4	2	20
5-8	x		4		20
5-8		x	4		30
5-12		x	4		20
3-10		x	2		30
4-9		x	3		30
7-12		x	6		20
9-12		x	8		20

[1] All scores not indicated in the table are based upon 10 cases.

A. Results Based upon the Records of Animal Subjects

1. *The Influence of Two Directed Trials Introduced at Various Positions in the Learning Process*

Let it be recalled that there were three groups of animals which were guided for only two trials. One of these groups was controlled in the first and second trials; another, in the sixth and seventh trials; the third group, in the eleventh and twelfth trials. For convenience, the groups will be designated by the numbers

2 (1-2), 2 (6-7), 2 (11-12), respectively. In the tables and throughout the discussion the first digit in the configuration will be used to indicate the amount of guidance, while the figures in brackets will indicate the trials in which guidance was given.

TABLE 2. INFLUENCE OF TWO DIRECTED TRIALS UPON TRIALS—ANIMAL SUBJECTS

Group	Trials	Absolute Saving	Relative Saving (Per Cent)
2 (1-2)	25.5	8.3	24.67
2 (6-7)	28.8	5.0	14.70
2 (11-12)	31.9	1.9	5.60

Influence upon trials: It is apparent from Table 2 that the control in the three positions acts to reduce the number of trials required for learning the maze; and its efficiency is greatest when it is introduced in the initial trials. This beneficial effect decreases as the series of guided runs is removed farther from the beginning.

It should be noted that the probable errors are not given in the tables. Because of the ambiguity of the meaning of this measure when based upon so few cases, its omission was deemed advisable. The reliability of the results may be judged by the consistency of the general tendencies exhibited.

The symbol of negativity employed in some of the subsequent tables also requires explanation. It is used when the score of the guided group is greater than that of the normal group. A negative saving, then, of an absolute or relative sort, means that the score of the controlled group exceeds absolutely or relatively that of the uncontrolled group by the amount indicated.

TABLE 3. INFLUENCE OF TWO DIRECTED TRIALS UPON TOTAL ERRORS—ANIMAL SUBJECTS

Group	Total Errors	Absolute Saving	Relative Saving (Per Cent)
2 (1-2)	143.22	16.93	10.57
2 (6-7)	120.16	39.99	24.97
2 (11-12)	145.70	14.45	9.02

Influence upon errors (Table 3): Guidance reduces the total number of errors made in the entire learning process. Group 2 (6-7) is the most benefited; groups 2 (1-2) and 2 (11-12) exhibit about the same amount of saving.

By a detailed examination of the error scores we may ascertain some of the factors and mechanisms which combined to produce the totals just described. The immediate effect of control in its most obvious form is the prevention of cul-de-sac errors. The number of cul-de-sac errors prevented during the control period is a function of the length of the directed series, as well as its position. In the later trials when, through the very nature of the learning process, fewer errors are being made than early in the learning, the influence of the guiding device as a means of preventing errors must necessarily decrease. For the same reason, as the series in any given position increases in length, the saving in cul-de-sac errors per trial decreases. But in this sheer physical prevention of cul-de-sac errors we have little interest. The truly significant immediate effect of the control will be revealed in the return error scores.

TABLE 4. IMMEDIATE INFLUENCE OF TWO DIRECTED TRIALS UPON ERRORS—ANIMAL SUBJECTS

A.

Group	Av. No. of Cul-de-sac Errors per Directed Trial	Absolute Saving	Relative Saving (Per Cent)
2 (1-2)	0	6.06	
2 (6-7)	0	3.89	
2 (11-12)	0	3.05	

B.

Group	Av. No. of Return Errors per Directed Trial	Absolute Saving	Relative Saving (Per Cent)
2 (1-2)	22.11	—1.00	—4.74
2 (6-7)	.55	2.41	81.42
2 (11-12)	1.95	—.92	—89.32

Table 4 indicates that the control has little, perhaps even a slightly deleterious, immediate effect, upon the return errors when it is introduced in the initial position. This unfavorable influence on return errors in the initial trials is, doubtless, a result of the fact that in the early stages of the learning, entrances into cul-de-sacs do operate to prevent complete returns to the beginning of the maze. When the cul-de-sacs are blocked, the animal which has once headed back toward the starting point has little to prevent a complete retracing of the pathway. Hence, when returns are the only possible errors, more of them are made than when cul-de-sacs may also waylay the victim.

Entrances into cul-de-sacs in the intermediate trials, on the other hand, instead of operating to prevent complete retracings, as they do in the initial trials, tend to increase the opportunity for retracing, for the return path in the first few sections of the maze, at least, has by the sixth trial, as a rule, been well mastered. Hence, when cul-de-sacs are blocked, the animal that is still in a somewhat exploratory stage of the learning and not greatly dependent on fixed cues, is guided easily forward to the goal. The difficulties and confusion caused by the cul-de-sacs is lacking. Confusion resulting from the novelty of the situation has worn off. This com-

plex of conditions is probably the explanation of the large absolute, as well as relative, saving in return errors in the sixth and seventh trials.

In the case of that group of animals for whom the guided series was most distantly removed from the beginning, however, a marked increase in return errors is exhibited during the period of control. The animal, presumably, by the eleventh trial has become greatly dependent on certain cues. Blocking the entrances to the cul-de-sacs modifies some of the cues, causes confusion, and, since return errors are the only ones possible, more of them are made than normally.

In our tabular analysis of the subsequent effect of control we shall consider only the average number of cul-de-sacs and the average number of return errors amassed per trial in the post-control period. For a more minute analysis of the subsequent influence of guidance, *i.e.*, the determination of the period of greatest influence, the persistence of the effect, the conflict of the distracting and beneficial forces, we may rely for our data on the learning curves.

TABLE 5. SUBSEQUENT EFFECT OF TWO DIRECTED TRIALS UPON ERRORS—ANIMAL SUBJECTS

A.

Group	Av. No. of Cul-de-sac Errors per Trial for Trials Subsequent to Control	Absolute Saving	Relative Saving (Per Cent)
2 (1-2)	2.12	—.14	—7.07
2 (6-7)	.93	.84	47.46
2 (11-12)	.92	.37	28.68

B.

Group	Av. No. of Return Errors per Trial for Trials Subsequent to Control	Absolute Saving	Relative Saving (Per Cent)
2 (1-2)	2.00	—.88	—85.98
2 (6-7)	.89	—.08	—9.87
2 (11-12)	.65	—.14	—27.45

Group 2 (1-2) manifests an increase above the normal in the average number of cul-de-sac errors amassed per trial for the period subsequent to the guided interval; groups 2 (6-7) and 2 (11-12) exhibit, on the other hand, a positive saving (see Table 5). Each of the groups, however, was unfavorably influenced, so far as the average number of return errors accumulated per trial in the post-control period is concerned, the relative loss being greatest for group 2 (1-2), least for group 2 (6-7). It is significant that the deleterious influence of the control is confined largely to the realm of the return errors and that in each group the return errors fare worse than the cul-de-sacs. Benefit, then, when it occurs, is in terms of a saving in those errors which, during the period of the control, had been prevented by physical force.

In order to make a more complete analysis of the influence of control upon errors, we have superimposed the curves of the directed groups upon that of the normal group. The discussion which follows is based upon a consideration of the relations between the scores of the normal and guided groups revealed by this device. Immediately following the period of control the curve of group 2 (1-2)[2] exhibits the large steeples which raise it alternately above and below the normal. After four trials characterized by this wavering, the curve of the directed group follows the normal fairly closely, but tends, on the whole, to fall slightly more rapidly and irregularly. The steeples following the period of control indicate confusion. It is significant that this wavering is short-lived. Reactions developed in the first two trials have little opportunity to become fixed, and, hence, the period of their effect is limited.

The curve for the group guided on the sixth and seventh trials (Figure 2) shows somewhat different characteristics. It remains below the normal curve following the period of direction, although exhibiting many steeples and a tendency to a slight rise in the eight trials subsequent to the control. After the period of the steeples, the curve follows that of the normal group with little significant

[2] Only a few typical curves are given. The reader may know that a curve has been omitted unless it is referred to by number in the text.

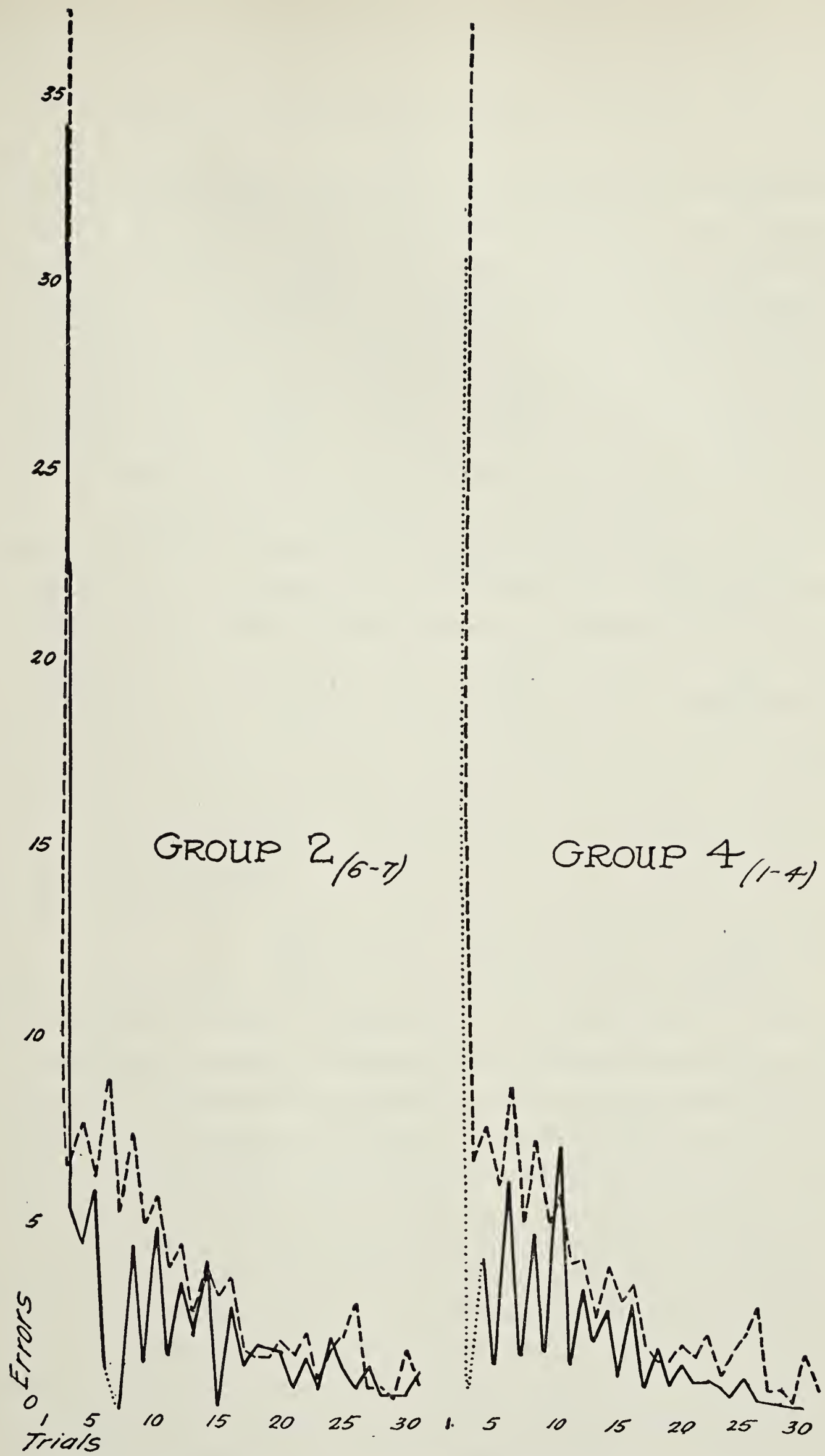

FIG. 2. A limited section of the error curve of groups 2 (6-7) and 4 (1-4) is shown superimposed upon the error curve of the unguided group. The dashes denote the unguided group; the dots, the guided trials of the guided groups; the solid line, the unguided trials of the guided groups.

deviation. The long period of wavering (extending over eight trials) is to be expected because the reactions to the maze situation formed in the trials previous to the period of guidance have become fairly clearly defined, though not rigidly fixed. The steeples may be interpreted, then, to represent the conflict between the somewhat flexible reactions established in the runs preceding the directed trials and the likewise unstable habits formed during the short period of control. The reactions most recently made seem, in general, to triumph over those most frequently made. Hence, the curve of the guided group remains below the normal.

The introduction of guidance in the eleventh and twelfth trials has apparently little subsequent effect upon the errors, for the curve of the guided group jumps back to the normal after the period of control and follows the normal fairly closely thereafter. Pronounced steeples are not present. The situation in the case of group 2 (11-12) probably differs from that of group 2 (6-7) in that the reactions to the maze have become well fixed by the eleventh trial. Alteration of the cues during the eleventh and twelfth runs causes confusion; but the change in the situation does not continue long enough to uproot habits previously well established. Consequently, when the control is removed, the animal readily slips back to his former modes of responding.

The important facts revealed by the error scores are as follows: (1) The influence of the control is selective. When errors are reduced in the runs subsequent to the guided trials they are largely those which were prevented during the period of guidance; namely, the cul-de-sac errors. Return errors tend to be slightly increased after the period of guidance. (2) Control causes, as well as prevents, errors. The total result is a balance of the two tendencies. (3) Control reduces the total number of errors made during the whole learning process. (4) Interpolation of direction in the intermediate position results, when any or all of the error scores are used as measures, in the greatest relative gain or the least relative harm. (5) Although the number of errors made per trial during the period subsequent to control may be increased, the mastery of the maze may still be attained more readily than when no guidance is administered.

TABLE 6. INFLUENCE OF TWO DIRECTED TRIALS UPON TIME—ANIMAL SUBJECTS

A.

Group	Total Time	Absolute Saving	Relative Saving (Per Cent)
2 (1-2)	1389.86	360.86	20.61
2 (6-7)	1587.95	162.77	9.30
2 (11-12)	1754.43	—3.71	—0.21

B.

Group	Av. Time per Directed Trial	Absolute Saving	Relative Saving (Per Cent)
2 (1-2)	367.82	142.69	27.95
2 (6-7)	25.07	23.02	47.87
2 (11-12)	34.63	—8.31	—31.57

C.

Group	Av. Time per Trial for Trials Subsequent to Control	Absolute Saving	Relative Saving (Per Cent)
2 (1-2)	33.56	—11.72	—53.66
2 (6-7)	20.78	—.11	—.53
2 (11-12)	21.24	—3.21	—17.80

Influence upon time (Table 6) : The influence of control upon the total time required to master the maze is, in general, beneficial. The time of group 2 (11-12), however, differs little from the normal. The efficacy of the guidance as a time-saving device varies inversely as the distance of the directed series from the initial trial.[3]

The immediate influence of guidance upon time is beneficial, if the period of control is not too far removed from the initial trials. In group 2 (11-12), however, an increase in time is exhibited. Group 2 (6-7) manifests a greater relative gain than group 2 (1-2).

Of the two groups, 2 (1-2) and 2 (11-12), showing a large increase in time per trial in the runs following the period of guid-

[3] The time scores throughout the monograph are stated in seconds.

ance, group 2 (1-2) sustains the greatest relative loss. This deleterious subsequent effect of control, besides being a result of distraction, may be a function of the insufficient opportunity to gain great facility in running the true pathway of the maze, which results from the decrease in the number of trials. That this latter factor is not alone operative, however, is evident from the fact that the relative loss in the three groups does not vary consistently with the number of trials saved.

Conclusion: The influence of control upon total time, errors and trials is beneficial. The degree of benefit in trials and total time is inversely proportional to the distance of the directed series from the initial trials. The intermediate position of the guided series seems most favorable to the reduction of errors. The immediate effect of control in the initial position and in the position most distantly removed from the early trials is to increase the number of return errors. The subsequent effect of guidance upon time and return errors is deleterious.

2. *Influence of Four Directed Trials Introduced at Various Positions in the Learning Process*

Let it be recalled that four groups of animals were guided for a series of four successive trials. Control was administered from the first to the fourth, from the fifth to the eighth, from the ninth to the twelfth, and from the thirteenth to the sixteenth trials in the various groups.

TABLE 7. INFLUENCE OF FOUR DIRECTED TRIALS UPON TRIALS—ANIMAL SUBJECTS

Group	Trials	Absolute Saving	Relative Saving (Per Cent)
4 (1-4)	22.0	11.8	34.9
4 (5-8)	28.1	5.7	16.9
4 (9-12)	29.1	4.7	13.9
4 (13-16)	28.8	5.0	14.8

Influence upon trials (Table 7) : The positive influence of these four-trial series upon the total number of trials necessary to master

the problem manifests, in general, as in the two-trial series, a decreasing magnitude the farther the position of the series is from the initial trial. The most marked increase in the number of trials —perhaps the only significant increase—resulting from position differences in the controlled series appears between groups 4 (1-4) and 4 (5-8). There is little difference in the amount of saving in groups 4 (5-8), 4 (9-12) and 4 (13-16).

TABLE 8. INFLUENCE OF FOUR DIRECTED TRIALS UPON TOTAL ERRORS—ANIMAL SUBJECTS

Group	Total Errors	Absolute Saving	Relative Saving (Per Cent)
4 (1-4)	99.90	60.25	37.62
4 (5-8)	107.71	52.44	32.74
4 (9-12)	133.03	27.12	16.93
4 (13-16)	144.65	15.50	9.68

Influence upon errors: As in the case of trials, the control, while always resulting in a saving, decreases in efficiency the more distant is its point of introduction from the beginning of the learning. The total error score (see Table 8) shows a regular increase from groups 4 (1-4) to 4 (13-16).

The immediate effect, as we have previously indicated, is a function of the sheer physical prevention of cul-de-sac errors and a less tangible influence upon return errors. It is obvious that the number of cul-de-sac errors which the control has opportunity to prevent, decreases in accordance with the nature of the learning process by which the maze is mastered, as the series of directed trials is removed farther from the beginning. A discussion of the influence of this physical factor we shall omit in the subsequent presentation of results.

The return errors amassed per trial during the period of control (see Table 9) are considerably greater in number in three of the groups than those made in the corresponding trials of the normal group. The increase above the normal of the return errors in the initial trials we have accounted for on the basis of a tendency to complete retracings when cul-de-sacs are not present.

TABLE 9. IMMEDIATE EFFECT OF FOUR DIRECTED TRIALS UPON ERRORS—ANIMAL SUBJECTS

A.

Group	Av. No. of Cul-de-sac Errors per Directed Trial	Absolute Saving	Relative Saving (Per Cent)
4 (1-4)	0	4.90	
4 (5-8)	0	3.81	
4 (9-12)	0	3.47	
4 (13-16)	0	2.45	

B.

Group	Av. No. of Return Errors per Directed Trial	Absolute Saving	Relative Saving (Per Cent)
4 (1-4)	14.54	—1.57	—12.10
4 (5-8)	2.89	.11	3.67
4 (9-12)	2.23	—1.12	—100.90
4 (13-16)	1.37	—.47	—52.22

The negative saving in the latter trials, it is reasonable to believe, results from the conflict of habits arising from the alteration in the sensory cues. The balance of factors probably contributing to the slight positive saving in the return errors amassed in the directed trials which are inserted in an intermediate position, we have described in the discussion upon the influence of two controlled trials.

The subsequent effect of guidance (see Table 10), so far as cul-de-sac errors are concerned, is beneficial. The relative positive effect upon cul-de-sac errors amassed per trial increases the more distantly removed (within certain limits) the guided series is from the initial trials. This effect reaches its maximum in the last few of the first twelve trials and decreases thereafter. Guidance late in the learning can do little but interfere with a well-nigh perfected reaction to the maze situation.

It is significant, moreover, that in each of the groups the saving in the realm of cul-de-sac errors in the post-control trials is greater than in the realm of return errors. In other words, those errors which were previously prevented are those which are relatively most reduced after guidance ceases.

TABLE 10. SUBSEQUENT EFFECT OF FOUR DIRECTED TRIALS UPON ERRORS—ANIMAL SUBJECTS

A.

Group	Av. No. of Cul-de-sac Errors per Trial for the Trials Subsequent to Control	Absolute Saving	Relative Saving (Per Cent)
4 (1-4)	1.46	.85	36.79
4 (5-8)	1.01	.60	37.27
4 (9-12)	.75	.54	41.86
4 (13-16)	.70	.19	21.35

B.

Group	Av. No. of Return Errors per Trial for the Trials Subsequent to Control	Absolute Saving	Relative Saving (Per Cent)
4 (1-4)	1.03	—.29	—39.18
4 (5-8)	.57	.16	21.92
4 (9-12)	.45	.06	11.76
4 (13-16)	.77	—.38	—97.44

The return errors made per trial are increased above the normal in the post-control period when the guidance is administered in the initial trials or late in the learning process. The negative saving in group 4 (1-4) is probably the result, to a large extent, of the retracing habit set up in the initial trials and accentuated by confusion resulting from changed sensory cues upon the removal of the controlling device. In group 4 (13-16), however, we have reason to believe that this apparently great increase in return errors is a function of the distracting effects of the control, for group 4 (9-12), which exhibits a greater relative loss during the period of direction, nevertheless, manifests a gain in the post-control period. The length of the guided series, we may argue, was not sufficient to permit an adjustment to the cues substituted for those fixed through twelve trials of practice. The conflict, then, of the partially completed readjustment habits with the old habits may have been the cause of the increase in errors. Confusion need not have been very pronounced, however, to have given rise to the

apparently enormous relative increase in return errors, since a single return error in these later trials has great weight.

The error curves of the four groups may be compared on the basis of regularity and speed of decline, as well as position above and below the normal. Each one of the curves, following the control period, begins below the normal. The post-control period is characterized by steeples which lie either on a rising or level curve, thus indicating a time of great uncertainty on the part of the rats. These steeples persist for six trials in the case of the groups 4 (5-8), 4 (9-12) and 4 (13-16), and for ten trials in the case of the group guided in the initial runs (Figure 2). The steeples are not sufficiently high, except in the case of group 4 (13-16), to cause the curve of the controlled group to cross the normal for more than one trial. It is significant that, while the group guided in the initial trials shows the greatest disturbance, a readjustment is readily effected and the curve sinks rapidly, whereas, when control is introduced later in the learning process, a rapid fall is not apparent.

Influence upon time (Table 11) : In all but one group, guidance reduces the total time required to perfect the reaction to the maze situation. The factors influential in producing these totals will be revealed, in part, by an inspection of the time scores for the control and post-control periods, as well as the scores in trials.

The immediate effect of guidance introduced early in the learning, when habits are in a fluid state, is a reduction in the time. If control is introduced later, when habits have crystallized, a marked loss is evidenced. This same detrimental influence of control interpolated at a position too remote from the initial trials was manifested in the error scores. Time and error are, of course, dependent variables. Whether or not time increases independently of errors matters little, for an increase in one or both may easily be accounted for in terms of the confusion resulting from the alteration of sensory cues which had been well integrated into the habitual reactions.

With the exception of group 4 (5-8) all groups manifest in the post-control period a considerable increase above the normal in the average time consumed per trial. This increase, however, in

TABLE 11. INFLUENCE OF FOUR DIRECTED TRIALS UPON TIME—ANIMAL SUBJECTS

A.

Group	Total Time	Absolute Saving	Relative Saving (Per Cent)
4 (1-4)	1298.97	451.75	25.80
4 (5-8)	1547.30	203.42	11.61
4 (9-12)	1841.39	—90.67	—51.79
4 (13-16)	1722.91	27.81	15.89

B.

Group	Av. Time per Directed Trial	Absolute Saving	Relative Saving (Per Cent)
4 (1-4)	234.87	76.59	24.59
4 (5-8)	33.96	13.87	29.00
4 (9-12)	46.28	—19.94	—75.70
4 (13-16)	31.66	—11.63	—58.06

C.

Group	Av. Time per Trial for the Trials Subsequent to Control	Absolute Saving	Relative Saving (Per Cent)
4 (1-4)	30.99	—9.62	—45.01
4 (5-8)	18.45	.30	1.60
4 (9-12)	25.37	—7.34	—40.71
4 (13-16)	19.59	—2.48	—14.49

time per trial is not entirely unambiguous as an index of the nature of the influence of the control. All of the groups exhibit a saving in trials. Although a reduction in time is a function of the accuracy of the reaction to the maze, the number of errors made, it is also a function of the speed of running which is attained as a result of practice, as well as confidence gained with experience. The slight saving in group 4 (5-8) is significant because it occurs in spite of a reduction in trials. The fact, furthermore, that the increase in time is not directly proportional to the reduction in errors indicates that control does have an influence upon time which is independent of trials.

The time curves for the groups guided for four trials reveal little that has not been indicated in the tables, except that in the final stages of the learning the time scores lie below the normal; *i.e.,* the ultimate effect of control upon time is beneficial. Steeples indicating uncertainty are unequivocally present in the case of the curves for groups 4 (1-4), 4 (9-12) and 4 (13-16). The steeples, as well as the subsequent descent of the curve, are greater for group 4 (1-4) than for group 4 (9-12) or 4 (13-16). This indicates greater confusion, but more rapid readjustment when control is introduced in the initial trials.

Conclusion: In general, the saving in total trials, time and errors is positive and varies inversely as the distance of the directed series from the early trials. The initial position is decidedly most favorable to the reduction of trials. The saving in errors, considered independent of trials, is largely in the realm of cul-de-sac errors. The effect of control upon return errors is, in general, detrimental. Especially is this true when guidance is interpolated in the initial trials or in positions well removed from the beginning.

3. *Influence of Six Directed Trials Introduced at Various Positions in the Learning Process*

The series of six successive directed trials were introduced upon the first, fourth and seventh run.

TABLE 12. INFLUENCE OF SIX DIRECTED TRIALS UPON TRIALS—ANIMAL SUBJECTS

Group	Trials	Absolute Saving	Relative Saving (Per Cent)
6 (1-6)	15.5	18.3	54.14
6 (4-9)	18.3	15.5	45.86
6 (7-12)	29.7	4.1	12.13

Influence upon trials (Table 12): As are lesser amounts of guidance, so the series of six directed trials are effective in reducing the total number of runs required to master the problem. The effectiveness of the control, as an agent for decreasing the total

trials, diminishes as its point of interpolation is removed more distantly from the initial runs.

TABLE 13. INFLUENCE OF SIX DIRECTED TRIALS UPON ERRORS—ANIMAL SUBJECTS

A.

Group	Total Errors	Absolute Saving	Relative Saving (Per Cent)
6 (1-6)	69.73	90.42	56.46
6 (4-9)	73.55	86.60	54.07
6 (7-12)	116.16	43.99	27.47

B.

Group	Av. No. of Return Errors per Directed Trial	Absolute Saving	Relative Saving (Per Cent)
6 (1-6)	10.87	—2.05	—23.24
6 (4-9)	.37	1.96	84.12
6 (7-12)	1.38	.32	18.82

C.

Group	Av. No. of Cul-de-sac Errors per Trial for Trials Subsequent to Control	Absolute Saving	Relative Saving (Per Cent)
6 (1-6)	.43	1.32	75.43
6 (4-9)	.54	.95	63.76
6 (7-12)	.70	.59	45.73

D.

Group	Av. No. of Return Errors per Trial for Trials Subsequent to Control	Absolute Saving	Relative Saving (Per Cent)
6 (1-6)	.60	.28	31.82
6 (4-9)	.51	.14	21.54
6 (7-12)	.45	.06	11.76

Influence upon errors (Table 13): A similar tendency for the effectiveness of the control to decrease, the later it is given in the

learning process, is evident in the total error scores. The initial and intermediate positions, however, differ relatively little in effectiveness.

The immediate result of the control, measured in terms of return errors, manifests, likewise, the same tendencies that we have noted in our consideration of the influence of various other amounts of guidance. The number of return errors accumulated during the directed series in the initial position is greater than that amassed by the normal group. The usual negative saving in the directed trials interpolated in the final position is not present, though in comparison with group 6 (4-9), a decided decrease in relative saving is shown. Since the point of the introduction of the control, as the series grows longer, occurs earlier in the learning process—when habits have not become well fixed—it is reasonable to expect that the most distracting effect would not be so prominent, and hence, a saving in return errors more probable, than in the case of the shorter series.

The subsequent influence of the control upon the errors, both return and cul-de-sac, made per trial is beneficial; but the relative saving decreases the farther the position of the directed series is from the initial trial. Again, it is worthy of note that the saving in cul-de-sac errors is much greater in each group than the relative saving in return errors.

The error curves reveal little that is new. The curve for group 6 (1-6) begins, subsequent to the period of direction, below the normal curve. It exhibits only one steeple and then falls rapidly and regularly to the base line. In no place does it rise above the normal curve. The curve for group 6 (4-9) (Figure 3) rises in the trials immediately succeeding the period of guidance, but crosses the normal curve only once. It has three pronounced steeples before beginning its decline, which, when once started, is rapid and fairly regular. The curve for group 6 (7-12), on the other hand, does not manifest very marked steeples. While it does start below the normal in the post-control period it quickly rises to meet the normal and follows the latter closely. The persistence of the effect of the guided series, when it is introduced late in the learning process, as well as the magnitude of the effect, is slight.

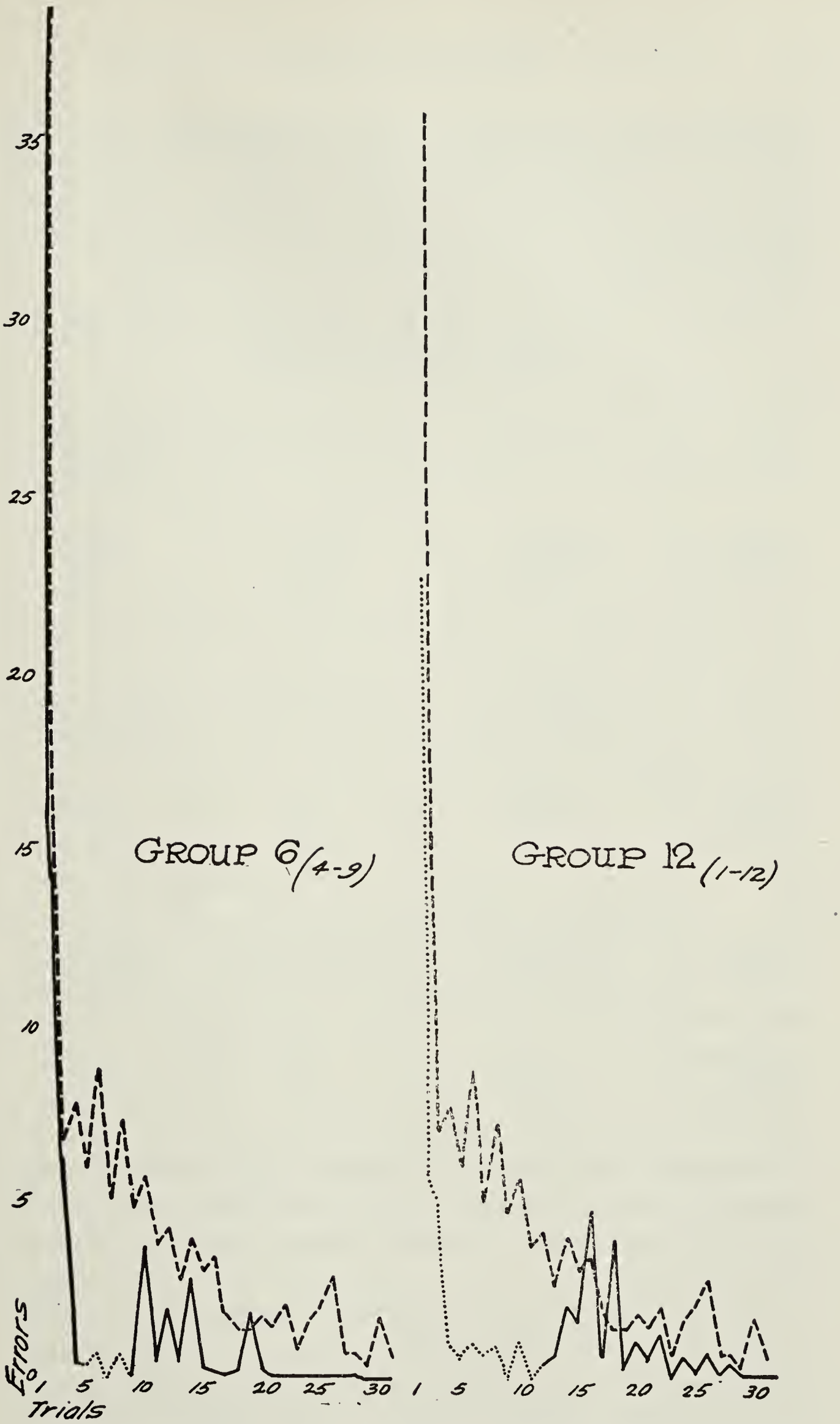

FIG. 3. A limited section of the error curve of groups 6 (4-9) and 12 (1-12) is shown superimposed upon the error curve of the unguided group. The dashes denote the unguided group; the dots, the guided trials of the guided groups; the solid line, the unguided trials of the guided groups.

The curves, then, reveal that (1) the most persistent effect is apparent when the earlier trials are guided; (2) the wavering produced by the abstraction of the control is greatest in the intermediate period; and (3) that the least effect is exhibited under the condition in which control occurs late in the learning.

TABLE 14. INFLUENCE OF SIX DIRECTED TRIALS UPON TIME—ANIMAL SUBJECTS

A.

Group	Total Time	Absolute Saving	Relative Saving (Per Cent)
6 (1-6)	1079.61	671.11	38.33
6 (4-9)	1238.94	511.78	29.23
6 (7-12)	1628.95	121.77	6.96

B.

Group	Av. Time per Directed Trial	Absolute Saving	Relative Saving (Per Cent)
6 (1-6)	174.59	2.10	1.19
6 (4-9)	20.58	14.41	41.19
6 (7-12)	25.77	4.18	13.95

C.

Group	Av. Time per Trial for Trials Subsequent to Control	Absolute Saving	Relative Saving (Per Cent)
6 (1-6)	18.24	1.78	8.89
6 (4-9)	14.15	4.95	25.92
6 (7-12)	18.26	—.23	—1.28

Effect upon time (Table 14) : The total time necessary for mastering the problem varies directly with the distance from the initial trial at which guidance is given. Control in all cases, however, reduces the time.

The immediate effect of the control upon time presents a slightly different picture. When guidance occurs in the initial position, its apparent influence is almost negligible; but when it occurs in the intermediate and final positions, a large relative saving is ex-

hibited. The marked reduction in time per trial for those trials in the intermediate position is probably mediated largely by the reduction in errors which we have already described.

Of the balance of factors tending to increase the time per run in the post-control period and those tending to facilitate the running, the latter are dominant in groups 6 (1-6) and 6 (4-9), but most influential in the case of group 6 (4-9). The slight increase in time per trial for the trials following the directed series in group 6(7-12) is significant, since it is the only hint we have of the usual confusion attendant upon the late introduction of the control. The distracting phase of the control's influence was not manifested in the error scores as it usually is.

The time curves add little to the information furnished by the tables, except in regard to the persistence of the influence of the control. The time curve for group 6 (1-6) starts, in the period subsequent to the control, below the normal and, like the error curve for the same group, has one marked steeple before its regular descent begins. The curve for group 6 (4-9) remains always below the normal; but a series of small steeples indicate that confusion was operative over a longer period than in the previous group. The curve for group 6 (7-12), on the other hand, crosses and lies above the normal curve for some time. Its descent is slow, but slightly more regular than that of the normal curve.

Conclusion: The efficacy of the control, measured in terms of total trials, total errors and total time, varies inversely with the distance of the guided series from the initial run. Guidance given in the intermediate position is favorable in its immediate effect upon both time and errors; and the relative degree of its influence is greater than that of control occurring earlier or later. The subsequent effect of the control upon errors is favorable. It is greater in the realm of the cul-de-sac than return errors, and varies for both types inversely as the distance of the directed trials from the beginning of the learning process.

4. *Influence of Eight Directed Trials Introduced at Various Positions in the Learning Process*

Three positions of a series of eight successive trials were employed. The guided series began upon the first trial, the third trial and the fifth trial.

TABLE 15. INFLUENCE OF EIGHT DIRECTED TRIALS UPON TRIALS—ANIMAL SUBJECTS

Group	Trials	Absolute Saving	Relative Saving (Per Cent)
8 (1-8)	19.9	13.9	41.12
8 (3-10)	30.6	3.2	9.46
8 (5-12)	26.8	7.0	20.71

Influence upon trials (Table 15) : All groups exhibit a positive saving in trials; but in this series we meet the first exception to the rule that the efficacy of the control, as measured in terms of the number of trials required for learning the problem, varies inversely as the distance of the directed series from the initial trials. Group 8 (5-12) exhibits a greater saving in trials than does group 8 (3-10). For this no explanation is apparent except that of the chance assembling in one group of several animals which behaved eccentrically. One animal, for instance, after he had practically mastered the problem, consumed twenty-six trials in the elimination of one error.

Influence upon errors (Table 16) : Guidance effects a marked positive saving in the total number of errors made by each of the three groups. The initial position seems most efficient for error reduction. The intermediate and final positions of the control seem about equally effective.

The immediate influence of guidance administered for eight trials shows some tendencies not hitherto displayed. The positive saving in return errors made during the period of control which includes the initial trials is contrary to our usual findings. That it is no chance result is supported by the fact that the average number of return errors made in the first twelve trials by the

TABLE 16. INFLUENCE OF EIGHT DIRECTED TRIALS UPON ERRORS—ANIMAL SUBJECTS

A.

Group	Total Errors	Absolute Saving	Relative Saving (Per Cent)
8 (1-8)	71.53	88.62	55.34
8 (3-10)	108.63	51.52	32.17
8 (5-12)	107.71	52.44	32.74

B.

Group	Av. No. of Return Errors per Directed Trial	Absolute Saving	Relative Saving (Per Cent)
8 (1-8)	5.84	1.08	15.67
8 (3-10)	1.61	.59	26.82
8 (5-12)	2.43	—.23	—10.45

C.

Group	Av. No. of Cul-de-sac Errors per Trial for Trials Subsequent to Control	Absolute Saving	Relative Saving (Per Cent)
8 (1-8)	.45	1.16	72.05
8 (3-10)	.93	.46	33.09
8 (5-12)	.70	.59	45.73

D.

Group	Av. No. of Return Errors per Trial for Trials Subsequent to Control	Absolute Saving	Relative Saving (Per Cent)
8 (1-8)	.30	.43	58.90
8 (3-10)	.95	—.35	—58.33
8 (5-12)	.50	.01	1.99

group guided during these runs also exhibits a saving (of 29%) over the normal. The hypothesis previously advanced that cul-de-sacs do prevent complete retracings and hence their absence increases the return error score applies, then, only to the first six trials. The groups guided for more than six of the initial trials

have practically mastered the true pathway of the maze. The retracing habit is readily eliminated in a cul-de-sac-less maze, as soon as the association between food and the maze situation has been well established.

The negative saving in the number of return errors made during the period of control by the group whose guided trials were most distantly removed from the initial run is in accord with a tendency which we have previously noted and accounted for on the basis of confusion resulting from the altered sensory cues.

The large positive saving in return errors in group 8 (3-10) is, probably, due to the fact that guidance was introduced sufficiently early to avoid conflict with any fixed maze habits and to prevent the formation of any elaborate retracing habits resulting from the absence of cul-de-sacs.

In all of the records used to analyze the effect of control upon the behavior in the post-control period, the three groups we are discussing maintain the same relative rank. Group 8 (1-8) ranks first; group 8 (5-12), second; and group 8 (3-10), third. The saving in cul-de-sac errors is greater than in the realm of return errors in each of the groups. It is significant, also, that initial guidance, as in the case of the six-trial series, is the most beneficial in its subsequent influence. Probably two alterations of sensory cues (the introduction and removal of the control), if the guided series is sufficiently long to permit the development of a genuine dependence upon the cues, are more disturbing than one alteration; namely the mere removal of the control.

The rather high cul-de-sac error score of group 8 (3-10) for the post-control period is somewhat difficult to account for, except in terms of chance. The fact that the group which did excel during the period of guidance suffers this increase in return errors in the trials following the period of guidance, gives plausibility to the explanation couched in terms of chance. It is possible, of course, that change of cues upon the eleventh trial is particularly disrupting. This assumption of the unique nature of the eleventh trial seems, however, fanciful to the writer.

The curves of all the groups show a marked wavering in the post-control period. The curve of group 8 (1-8), which through-

out all its course remains below the normal, exhibits small steeples for eleven trials immediately after guidance, then drops suddenly and regularly to the base line. The curve for group 8 (3-10) starts below the normal curve in the post-control period; but its steeples, which persist for about eleven trials, rise alternately above and below the normal. Subsequent to this period of rather conspicuous wavering, the curve follows the general course of the normal curve. The curve for group 8 (5-12) exhibits a period of wavering covering seven trials, in which the steeples rise alternately above and below the normal. In the latter part of its course the curve sinks below the normal and remains consistently slightly below. While the period of wavering has about the same extent in all of the groups, the readjustment, as we have frequently indi-

TABLE 17. INFLUENCE OF EIGHT DIRECTED TRIALS UPON TIME—ANIMAL SUBJECTS

A.

Group	Total Time	Absolute Saving	Relative Saving (Per Cent)
8 (1-8)	1076.73	673.99	38.50
8 (3-10)	1537.65	213.07	12.17
8 (5-12)	1476.37	274.35	15.67

B.

Group	Av. Time per Directed Trial	Absolute Saving	Relative Saving (Per Cent)
8 (1-8)	88.60	16.57	15.76
8 (3-10)	27.67	10.16	26.86
8 (5-12)	25.85	6.46	19.99

C.

Group	Av. Time per Trial for Trials Subsequent to Control	Absolute Saving	Relative Saving (Per Cent)
8 (1-8)	13.72	5.03	26.83
8 (3-10)	19.20	—.25	—1.32
8 (5-12)	14.32	3.71	20.58

cated, is more rapid and regular when guidance is administered in the initial trials.

Influence upon time (Table 17): The records and curves reveal few tendencies which could not have been predicted from the error records and accounted for on the basis of the same factors operative in making the error records as they are. A detailed discussion of the results would accomplish little.

Conclusion: Eight directed trials introduced in the initial position are most effective in reducing trials, errors and time; eight controlled trials in the intermediate position are least effective, though still beneficial.

B. Results Based upon the Records of Human Subjects

Our general method of deriving scores we have already discussed at the beginning of the chapter. Table 18 merely furnishes the data with respect to the number of cases used in computing the scores based upon the records of the human subjects.

1. *Influence of Two Directed Trials Introduced at Various Positions in the Learning Process*

In the experiment conducted upon human subjects, six groups were guided for two successive trials. The introduction of the directed series occurred in the various groups upon the first, third, fifth, seventh, ninth and eleventh trial, respectively. The groups so guided will be referred to as H2 (1-2), H2 (3-4), H2 (5-6), H2 (7-8), H2 (9-10) and H2 (11-12).

Influence upon trials (Table 19): With one exception, two directed trials, whatever their position, have a beneficial effect, when this effect is measured in terms of the number of trials required to master the problem. Guidance in the initial trials acts to reduce the number of runs. Control in the third and fourth trials, on the other hand, effects a marked increase above the normal in the number of runs required; but after the fourth trial, guidance again results in a saving which increases as the series is interpolated farther and farther from the beginning. There is, however, an optimum position (ninth and tenth trials) beyond which the efficacy of the control appears to decrease. This is at variance

TABLE 18. NUMBER OF CASES USED IN COMPUTING A GIVEN SCORE—HUMAN SUBJECTS[4]

Serial Number of the Trials for which an Average is Sought	Nature of the Trials		No. of Uncontrolled Trials Preceding Trials for which an Average Score is Sought	No. of Controlled Trials Preceding Trials for which an Average Score is Sought	No. of Cases upon which Average is Based
	Controlled	Uncontrolled			
1-2		x			100
3-4		x	2		90
1-4		x			90
5-6		x	4		70
1-6		x			70
7-8		x	4		50
1-8		x			50
5-6	x		4		20
5-8		x	4		50
7-8	x		6		20
9-10	x		8		30
1-2	x				50
3-4	x			2	40
1-4	x				40
5-6	x			4	30
1-6	x				30
7-8	x			6	20
1-8	x				20
11-12	x		8	2	20
9-12	x		8		20

[4] All scores not indicated in the table are based upon 10 cases.

TABLE 19. INFLUENCE OF TWO DIRECTED TRIALS UPON TRIALS—HUMAN SUBJECTS

Group	Trials	Absolute Saving	Relative Saving (Per Cent)
H2 (1-2)	36.9	7.4	16.70
H2 (3-4)	50.4	—6.1	—13.77
H2 (5-6)	43.0	1.3	2.93
H2 (7-8)	41.1	3.2	7.22
H2 (9-10)	35.6	8.7	19.64
H2 (11-12)	38.3	6.0	13.54

with most of our findings in regard to the performance of the animals. Since human subjects differ from animals, at least in the amount of their ideational content, our explanations of this difference in results need not, then, be couched wholly in gross sensori-motor terms. Guidance in the initial trials prevents the formation of some bad habits and enters little into conflict with habits

already set up. In the later trials, when the maze habit is fairly well fixed, the control, while perhaps causing some confusion, does call the attention of the alert and analyzing human subject to certain of the critical elements of the situation. The location of the troublesome elements in the problem aids in a rapid adjustment. In the trials succeeding the first few, on the other hand, when the reaction is, at best, in a fluid state and cues have little meaning, changes in the situation tend to disrupt the proper habits that are in the process of fixation. Temporary hypotheses in regard to the correct path are demonstrated invalid, not because they were not in the first place proper, but because of the changing conditions of which the subject is not informed.

Whether the slight decline in the saving exhibited by group H2 (11-12) as contrasted with H2 (9-10) is a chance occurrence or a tendency that would clearly define itself were guidance interpolated at a number of positions subsequent to the twelfth trial, we can not say. A decrease in effectiveness, however, one would be justified in expecting. By the tenth trial, habits have, presumably, become so well ingrained that much of their plasticity has been lost. Guidance, at this stage or later, is more likely to be confusing, in certain of its aspects, than if it were introduced slightly earlier, although its total effect may still be favorable.

Influence upon errors (Table 20) : The total error scores show a tendency similar to that manifested in the trials. Initial guidance and the directed series located latest in the trial sequence are beneficial in their effects; control in the intermediate position is detrimental, or only slightly favorable. The large saving in group H2 (1-2) is significant. It supports the doctrine that it is better to avert bad habits than to disrupt them mechanically or call attention to them later in the learning.

The tendencies apparent in the scores indicating the immediate influences of the control are somewhat different from those evidenced in the scores made by the animals. The large saving in the return errors when guidance occurs early in the learning is one noteworthy deviation from the results obtained in the experiment upon rats. The stylus maze has, probably, difficulties for man that the large maze does not present to the animal. The turns in the

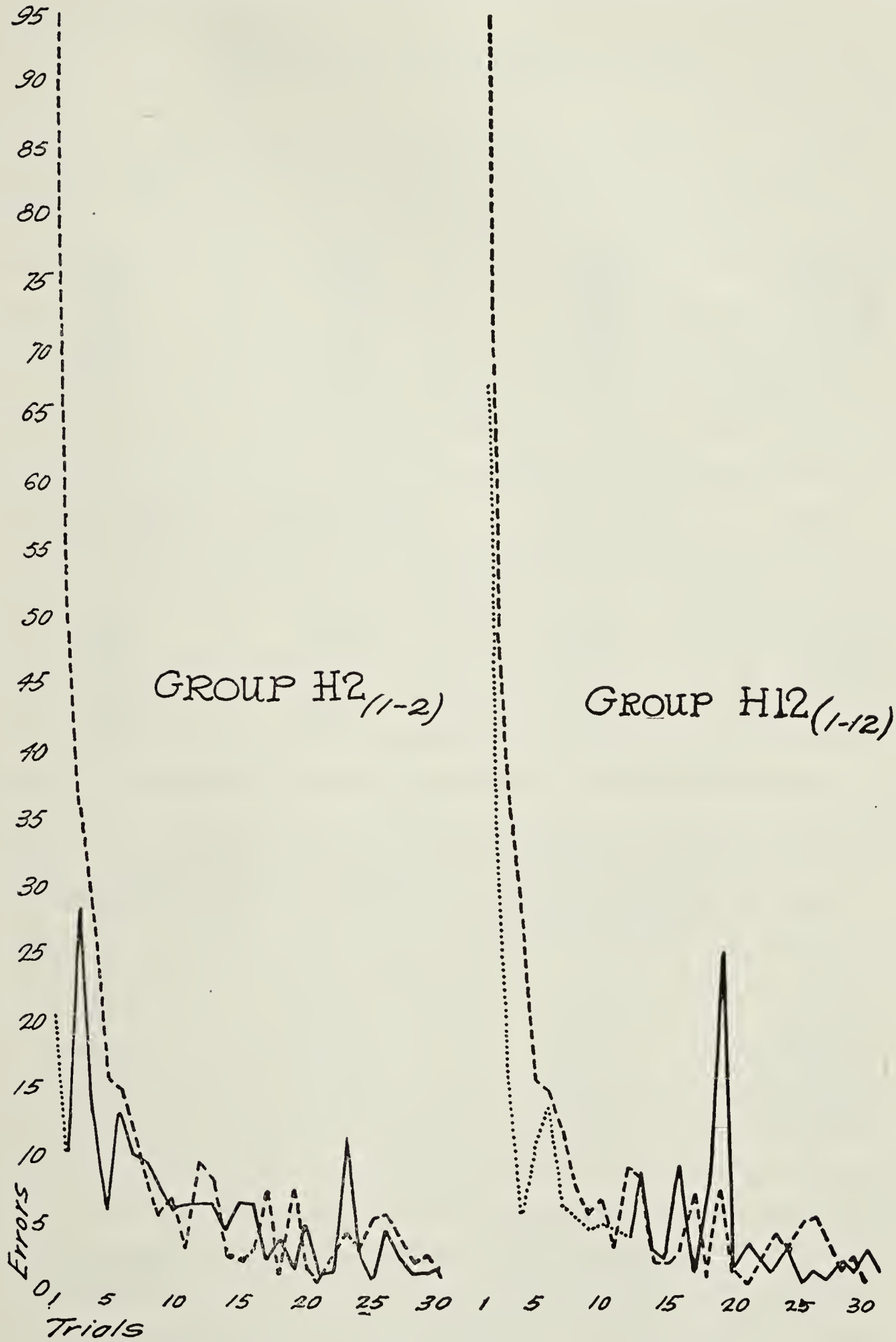

FIG. 4. A limited section of the error curve of groups H2 (1-2) and H12 (1-12) is shown superimposed upon the error curve of the unguided group. The dashes denote the unguided group; the dots, the guided trials of the guided groups; the solid line, the unguided trials of the guided groups.

TABLE 20. INFLUENCE OF TWO DIRECTED TRIALS UPON ERRORS—HUMAN SUBJECTS

A.

Group	Total Errors	Absolute Saving	Relative Saving (Per Cent)
H2 (1-2)	289.5	104.2	26.47
H2 (3-4)	410.2	—16.5	—4.19
H2 (5-6)	427.6	—33.9	—8.61
H2 (7-8)	378.3	15.4	3.91
H2 (9-10)	367.8	25.9	6.58
H2 (11-12)	355.5	38.2	9.70

B.

Group	Av. No. of Return Errors per Directed Trial	Absolute Saving	Relative Saving (Per Cent)
H2 (1-2)	39.15	17.20	30.53
H2 (3-4)	11.55	13.65	54.18
H2 (5-6)	9.68	1.94	16.84
H2 (7-8)	8.72	—1.94	—28.61
H2 (9-10)	9.57	—5.82	—155.20
H2 (11-12)	3.80	.35	8.43

C.

Group	Av. No. of Cul-de-sac Errors per Trial for Trials Subsequent to Control	Absolute Saving	Relative Saving (Per Cent)
H2 (1-2)	2.19	—.46	—26.59
H2 (3-4)	1.50	.04	2.60
H2 (5-6)	1.67	—.36	—27.48
H2 (7-8)	1.29	—.08	—6.61
H2 (9-10)	1.36	—.18	—15.25
H2(11-12)	1.16	—.18	—18.37

D.

Group	Av.No.of Return Errors per Trial for Trials Subsequent to Control	Absolute Saving	Relative Saving (Per Cent)
H2 (1-2)	3.39	—.51	—17.71
H2 (3-4)	3.28	—.88	—36.67
H2 (5-6)	2.74	—.89	—48.11
H2 (7-8)	2.06	—.46	—28.75
H2 (9-10)	1.75	—.41	—30.59
H2 (11-12)	1.52	—.18	—13.43

true pathway offer little obstruction to the rat; but to the human subject who is deprived of his faithful servant, vision, and is little at ease when relying entirely on contact or kinaesthesis for guidance, the small corners and turns of the true pathway, for no very small number of the early trials, act as effectively as obstructions to his progress as do the blind alleys. For minutes at a time he will work the stylus back and forth in a path that should offer him no resistance. Hence, the tendency to complete retracings in the cul-de-sac-less maze is not exhibited in the early trials, as it is in the case of the rats. Since, therefore, returns are not likely to be encouraged by the absence of cul-de-sacs, and no fixed habits are interfered with by the control, the marked relative saving in the initial trials is to be expected.

The distracting phase of the control's influence, as in the experiment upon animals, is on the ascendency, relatively at least, in the later trials. It is reasonable to suppose that the later the interpolation of the guidance occurs, and the more fixed the habits with which it enters into conflict, the more disturbing it will be. The positive saving in return errors exhibited by group H2 (11-12), which is an exception to the principle just enunciated, has the earmarks of a chance result. The fact that the normal score for the eleventh and twelfth trials is higher than that for the ninth and tenth is scarcely in accord with what we know of the learning process. Were the normal score for the eleventh and twelfth trials lower, or even the same as that for the ninth and tenth runs, an increase in return errors would have been exhibited.

Unlike the immediate effect of the control, the subsequent influence upon the errors amassed per trial is deleterious, and deleterious almost without exception. Cul-de-sac errors, moreover, are not spared; but it is worthy of note that the average number of cul-de-sac errors made per trial in the post-control period does not, in general, exhibit so large a relative increase over the normal as do the return errors. No very regular relation is apparent in the realm of cul-de-sac errors between the degree of relative detriment and the position of the guided series. From the point of view of the return errors amassed in the period following the directed

trials, the initial position and that latest in the trial sequence are the least detrimental.

This increase in errors over the normal in the human records, as contrasted with those of the rats', is, doubtless, a partial result at least, of the fact that the stylus maze entails such infinitely more delicate coördinations than does the large maze used for the animals that slight alterations are far more disrupting and not readily adjusted to. The human subject, moreover, was not informed that he was being guided. In his analyses, undoubtedly, the change in cues—when it is consciously recognized—is interpreted as the result of a false tracing or the entrance into regions yet unexplored. He declares himself "lost." A re-examination of the whole situation is attempted. This results, in the case of the short series, in much vain wandering and the deleterious habits dependent thereon. It must be remembered, however, that, in spite of this distracting effect of the control, a perfect adjustment to the maze situation is accomplished in fewer trials than normally.

Influence upon time (Table 21): The effect of guidance upon the total time required for mastering the problem is positive in all cases but one. The benefit, on the whole, however, is very slight. The only reduction in time of considerable size is effected by control interpolated late in the trial sequence.

The immediate influence of directed learning upon time is, in general, favorable. In the case of interpolated guidance there is a suggestion of a tendency for the relative saving in time during the period of control to decrease as the distance of the directed trials from the initial run is increased. The same tendency was present in the realm of return errors. Group H2 (11-12), in the case of both time and errors, exhibits a marked deviation from the general trend.

The subsequent effect of control upon the time consumed per trial is, in most cases, unfavorable, or so slightly favorable that it is of little significance. It is important to note, however, that guidance occurring within the first six trials has a very deleterious influence, whereas that occurring in the next six is less disturbing. The reason is not apparent. It is possible that at an early stage of the learning, when concepts are just taking form, alteration of

TABLE 21. INFLUENCE OF TWO DIRECTED TRIALS UPON TIME—HUMAN SUBJECTS

A.

Group	Total Time	Absolute Saving	Relative Saving (Per Cent)
H2 (1-2)	1573.69	33.72	2.10
H2 (3-4)	1569.12	38.29	2.38
H2 (5-6)	1759.48	—152.07	—9.46
H2 (7-8)	1587.92	19.49	1.21
H2 (9-10)	1389.19	218.22	13.57
H2 (11-12)	1479.50	127.91	7.96

B.

Group	Av. Time per Directed Trial	Absolute Saving	Relative Saving (Per Cent)
H2 (1-2)	199.85	50.40	20.14
H2 (3-4)	61.31	40.72	39.91
H2 (5-6)	49.07	2.92	5.61
H2 (7-8)	38.42	2.52	6.22
H2 (9-10)	41.07	—9.42	—29.76
H2 (11-12)	22.55	8.81	28.09

C.

Group	Av. Time per Trial for Trials Subsequent to Control	Absolute Saving	Relative Saving (Per Cent)
H2 (1-2)	35.84	—11.04	—44.52
H2 (3-4)	27.16	—4.16	—18.09
H2 (5-6)	27.79	—6.71	—31.83
H2 (7-8)	19.22	.69	3.46
H2 (9-10)	20.43	—1.63	—8.67
H2 (11-12)	18.20	—.28	—1.56

cues has a retarding effect upon speed. After, however, a general speed set has been established, the time required per trial may be little influenced by control. In fact, the slight increase in time exhibited by groups H2 (9-10) and H2 (11-12) in the post-control period may be explained in terms of the saving in trials and the consequent reduction in the practice which the subject gets in tracing the maze.

The curves reveal nothing that is not adequately depicted in the tables.

Conclusion: Control has a positive effect upon total trials, time and errors, when it is interpolated in the initial and latest positions, but is, generally speaking, detrimental in the intermediate position. The immediate effect of guidance is to reduce return errors in the early trials and to increase them above the normal in the later. The subsequent effect is to increase time and both types of error, but the degree of the detriment varies in no consistent way with the position of the control.

2. *Influence of Four Directed Trials Introduced at Various Positions in the Learning Process*

As in the experiment in which rats served as subjects, so here with the human subjects, a group was guided from the first to the fourth run, inclusive; another, from the fifth to eighth, inclusive; a third group, from the ninth to the twelfth run, inclusive.

TABLE 22. INFLUENCE OF FOUR DIRECTED TRIALS UPON TRIALS—HUMAN SUBJECTS

Group	Trials	Absolute Saving	Relative Saving (Per Cent)
H4 (1-4)	37.1	7.2	16.26
H4 (5-8)	43.7	.6	1.36
H4 (9-12)	37.5	6.8	15.35

Influence upon trials (Table 22): The influence of guidance extending over four successive runs and interpolated as described in the preceding paragraph, is manifested in a form similar to that displayed in the two-trial series. Initial guidance and that occurring latest in the trial sequence are about equally effective in reducing the number of trials; whereas the influence of control in the intermediate position upon trials is practically negligible. So considerable a deviation from the results of the experiment with animals, where the per cent of saving varies inversely as the distance of the guided series from the initial trial, is significant. It is possible, as we have previously indicated, that in the

intermediate stage of the learning, when hypotheses are being formed, a limited amount of control is very confusing. In the later trials, when the subject has become well oriented, the control, even though causing temporary confusion or systematic explorations, does, after all, indicate rather forcibly to the subject the troublesome elements in the situation and facilitates a rapid adjustment.

Influence upon errors (Table 23): The effect of guidance, from the point of view of the saving accomplished in the total number of errors made, varies inversely as the distance of the directed series from the beginning of the learning. The control introduced latest proves even detrimental. This is in striking contrast to the large saving in trials accomplished by the control thus interpolated. A probable explanation of this combination of effects was indicated in the discussion of the influence of guidance upon trials. The subject may be puzzled by the alteration of the situation, incident upon the introduction and removal of the control, may instigate somewhat systematic explorations and make many errors; but the critical elements of the situation have been called into the focus of his attention through the agency of the guiding device and conditions are ripe for a ready adjustment. Control occurring early in the learning, furthermore, when wandering is prevalent, has many more opportunities for preventing errors than that interpolated later.

The ranking of the groups in terms of the per cent of saving in return errors during the period of control is the same as that on the basis of total errors. The ascendency of the distracting phase of the control's influence, as the position of the directed runs is well removed from the beginning, is again evident; *i.e.*, the return error scores show a saving which varies inversely as the distance from the initial trial at which guidance is introduced. The large saving, when guidance is introduced in the initial trial, is noticeably contrary to the findings in the experiment in which rats served as subjects. The probable reason for the difference we have suggested in our discussion of the effect of two directed trials upon learning.

The subsequent influence of the control, considered both from

TABLE 23. INFLUENCE OF FOUR DIRECTED TRIALS UPON ERRORS—HUMAN SUBJECTS

A.

Group	Total Errors	Absolute Saving	Relative Saving (Per Cent)
H4 (1-4)	255.0	138.7	35.23
H4 (5-8)	378.5	15.2	3.86
H4 (9-12)	417.6	—23.9	—6.07

B.

Group	Av. No. of Return Errors per Directed Trial	Absolute Saving	Relative Saving (Per Cent)
H4 (1-4)	33.55	4.36	11.50
H4 (5-8)	8.30	.67	7.47
H4 (9-12)	5.81	—1.06	—22.23

C.

Group	Av. No. of Cul-de-sac Errors per Trial in Trials Subsequent to Control	Absolute Saving	Relative Saving (Per Cent)
H4 (1-4)	1.38	.16	10.31
H4 (5-8)	1.68	—.47	—38.84
H4 (9-12)	1.63	—.65	—66.32

D.

Group	Av.No.of Return Errors per Trial in Trials Subsequent to Control	Absolute Saving	Relative Saving (Per Cent)
H4 (1-4)	1.80	.60	25.00
H4 (5-8)	1.84	—.24	—15.00
H4 (9-12)	2.92	—1.58	—117.91

the point of view of cul-de-sac and return errors, becomes unfavorable, as the position of the guided series is shoved farther along in the learning. Guidance in the initial trials has a positive subsequent effect upon errors; the two other positions result in an increase in errors above the normal. An absolute, as well as

relative increase in errors per trial is, in general, manifested, the later the interpolation of the directed series. The large positive saving in trials for group H4 (9-12), then, becomes very significant, since it indicates that, in spite of a great disruption, rapid adjustment can take place.

Since in the records based on the performance of human subjects the subsequent effect of control is not consistently of greater relative magnitude in the realm of cul-de-sac than return errors, we must look for principles other than, and, perhaps, less mechanical than, the one of repetition which we used to explain the behavior of rats. Repetition may be a factor, but it is no longer the dominant one in producing the results. Ideational control is a possible factor. After an individual has succeeded in attaining the goal several times, he develops an idea of the general direction of the course he must pursue. When cues are altered and exploration follows, the reaction is likely to be more unfavorable—provided the subject does not become badly confused or completely lose himself—upon cul-de-sac errors than upon return errors, for, knowing in general the direction in which the goal is to be sought, the subject is loath to turn back on his path.

The error curves do little more than confirm the tabular evidence. In the period of control, the curve for group H4 (1-4) lies well below the normal, whereas in the post-control period, its general course differs little from the normal. The curve of group H4 (5-8) (Figure 5), on the other hand, exhibits steeples of medium height in the first seven trials of the post-control period, whereafter it follows the normal rather closely. These steeples carry it above the normal. The curve for group H4 (9-12) (Figure 5) has, immediately following the period of guidance, one very large steeple and one small one before it falls rapidly and regularly to about the level of the normal curve. Its subsequent course is slightly irregular. The enormous steeple coincides with what we have previously referred to as the period of somewhat systematic exploration. The curves, then, indicate longer wavering and less rapid adjustment when direction is given in the intermediate position; but more severe and shorter-lived confusion, when control is introduced late in the learning.

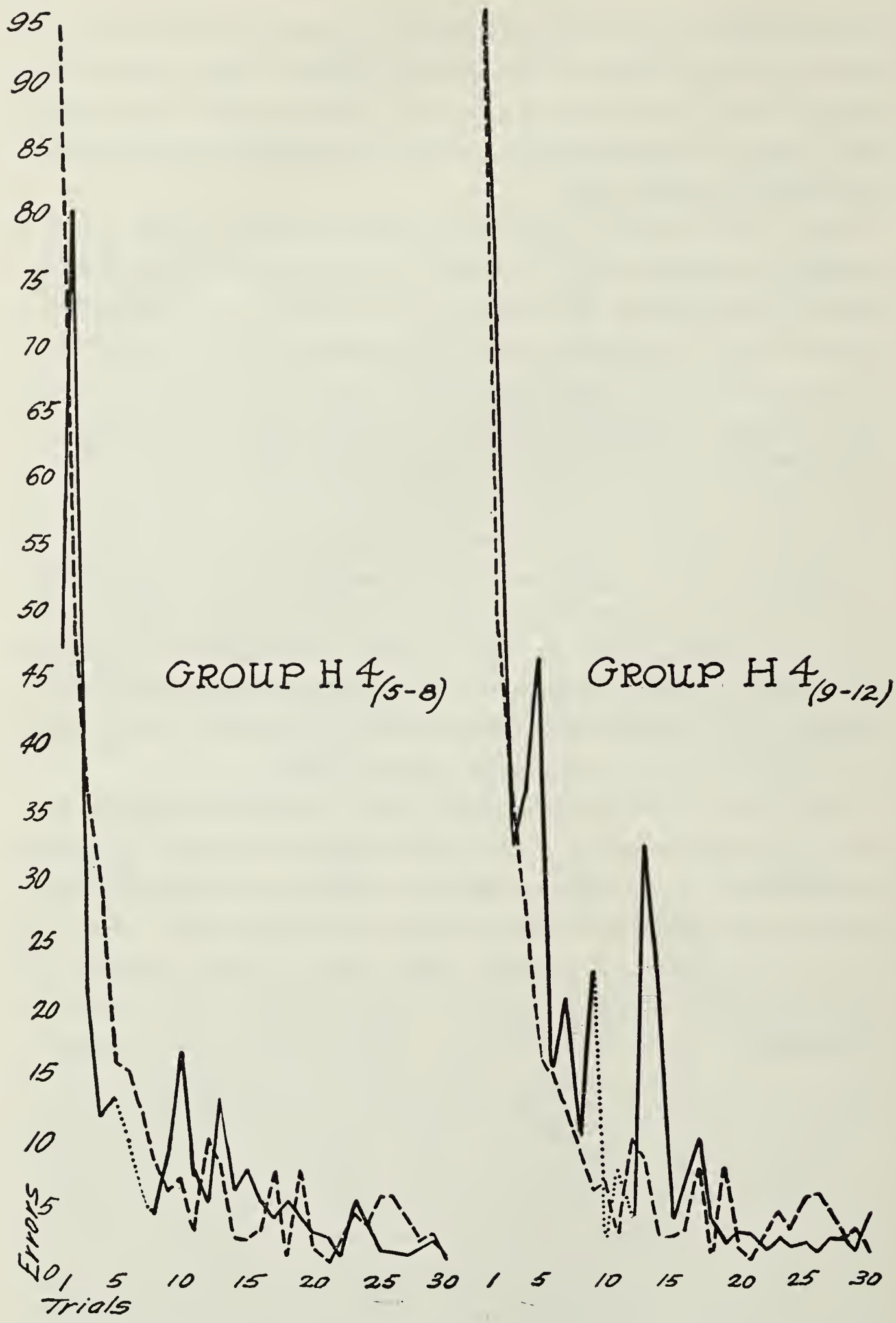

FIG. 5. A limited section of the error curve of groups H4 (5-8) and H4 (9-12) is shown superimposed upon the error curve of the unguided group. The dashes denote the unguided group; the dots, the guided trials of the guided groups; the solid line, the unguided trials of the guided groups.

Influence upon time (Table 24) : The scores indicating the total time required by the guided groups to master the problem exhibit only a slight saving over the time scores of the normal group. The immediate effect of the control in all positions is a positive saving, and the initial position seems the most favorable condition. The time per trial for the trials of the post-control period is, on the other hand, in the case of each directed group, in excess of the normal. The increase in time, over that of the normal, manifested by Group H4 (1-4), in spite of the decrease in errors, is significant.

The time curves in their relation to the normal in the post-control period resemble the error curves so closely, a discussion of them will be of no value.

Conclusion: In general, the effect of guiding four of the trials results in a slight but positive saving in the realm of total trials, total time and total errors. The immediate effect upon return errors varies inversely as the distance of the directed runs from the initial trial. This same inverse relationship between errors and the distance of the period of guidance from the initial stage of the learning holds for all of the error scores of the post-control period, as well as for the total number of errors amassed during the complete learning process. The intermediate position is least favorable to a reduction in trials, most favorable to a reduction in total time. The initial and final positions have about the same value, so far as these latter two measures are concerned. The immediate effect is to decrease the time; the subsequent effect is to increase the time consumed per trial.

TABLE 24. INFLUENCE OF FOUR DIRECTED TRIALS UPON TIME—HUMAN SUBJECTS

A.

Group	Total Time	Absolute Saving	Relative Saving (Per Cent)
H4 (1-4)	1548.63	58.78	3.66
H4 (5-8)	1597.22	10.19	0.63
H4 (9-12)	1566.48	40.93	2.57

B.

Group	Av. Time per Directed Trial	Absolute Saving	Relative Saving (Per Cent)
H4 (1-4)	149.92	17.60	10.50
H4 (5-8)	42.17	3.63	7.09
H4 (9-12)	32.73	3.46	9.57

C.

Group	Av. Time per Trial for Trials Subsequent to Control	Absolute Saving	Relative Saving (Per Cent)
H4 (1-4)	28.55	—5.55	—24.12
H4 (5-8)	22.90	—2.99	—15.02
H4 (9-12)	21.77	—3.85	—21.48

3. *Influence of Six Directed Trials Introduced at Various Positions in the Learning Process*

Only two groups of human subjects were granted series of six directed trials. One group was guided from the first to the sixth trial, inclusive; the other group, from the seventh to the twelfth run, inclusive.

Influence upon trials (Table 25) : Unlike the groups guided for the initial two or four trials, the saving in trials for group H6 (1-6) is practically negligible, and is far exceeded by the saving in the group guided in the later trials. The apparent ineffectiveness, so far as trials are concerned, of control doled out during the initial six runs, is significant, especially since, in the experiment conducted upon the rats, control in the initial six trials was the

TABLE 25. INFLUENCE OF SIX DIRECTED TRIALS UPON TRIALS—HUMAN SUBJECTS

Group	Trials	Absolute Saving	Relative Saving (Per Cent)
H6 (1-6)	43.6	.7	1.58
H6 (7-12)	37.1	7.2	16.24

most favorable condition for learning. Again we seem forced to seek an explanation in ideational terms. The six-trial series is apparently sufficiently long to permit the subject to develop a vague concept of the maze and a fair amount of confidence in his own procedure. When he does go astray, upon the removal of the controlling device, an emotional tone in the form of a feeling of discouragement becomes very pronounced and a vain search for the lost cues is instigated. This search, with its unsatisfied desire, tends to hinder a rapid and complete adjustment to the maze situation.

The same explanation for the saving in group H6 (7-12) as was advanced to account for the reduction in the number of trials required for learning in group H4 (9-12), may be offered. Repetition of the discussion is unnecessary.

Influence upon errors (Table 26): Although the adjustment is slower in the case of group H6 (1-6) than in group H6 (7-12), the saving in total errors is considerably greater. This saving, an inspection of the records reveals, is a result of the immediate physical effect of the control, and of control in the very early trials, especially.

The negative saving in the number of return errors accumulated during the period of control by group H6 (1-6), in contrast to the positive saving exhibited by group H6 (7-12), is significant. It is probably indicative of the operation of the same factors which produced the accentuation of the retracing reaction in the case of the animal groups guided for the initial two, four and six trials. Wandering characterizes the early stage of the learning. As soon as some familiarity with the maze is attained and the turns of the true path no longer act as barriers, the exploratory activities on

TABLE 26. INFLUENCE OF SIX DIRECTED TRIALS UPON ERROR—HUMAN SUBJECTS

A.

Group	Total Errors	Absolute Saving	Relative Saving (Per Cent)
H6 (1-6)	334.8	58.9	14.96
H6 (7-12)	380.3	13.4	3.40

B.

Group	Av. No. of Return Errors per Directed Trial	Absolute Saving	Relative Saving (Per Cent)
H6 (1-6)	30.52	—3.76	—12.32
H6 (7-12)	3.95	1.35	25.61

C.

Group	Av. No. of Cul-de-sac Errors per Trial for Trials Subsequent to Control	Absolute Saving	Relative Saving (Per Cent)
H6 (1-6)	1.75	—.44	—33.59
H6 (7-12)	1.16	—.18	—18.36

D.

Group	Av. No. of Return Errors per Trial for Trials Subsequent to Control	Absolute Saving	Relative Saving (Per Cent)
H6 (1-6)	3.53	—1.68	—90.81
H6 (7-12)	1.45	—.11	—8.21

the part of the guided subjects manifest themselves largely in long retracings which are unhampered by entrances into cul-de-sacs, as in the case of the unguided subjects.

Normally, the early stages of the learning are characterized by a rapid decline in return errors. The subject develops a notion of the general direction of the goal and some confidence in his procedure. Consequently, when control is interpolated after the sixth

trial, the simplification of the maze pattern operates principally to decrease below the normal the retracings.

The subsequent effect upon errors is negative in both types of error, thus indicating that the distraction resulting from alteration of cues rather than any beneficial effect of the control is dominant. Group H6 (1-6) suffers more than group H6 (7-12).

The error curve for group H6 (1-6) (Figure 6) through practically its entire course lies above the normal. Immediately subsequent to the guided trials a very large steeple appears. This is followed by a sudden drop in the curve and a series of smaller steeples whose general level is considerably below that of the first steeple, but still somewhat above the normal curve. These irregularities persist for about twenty trials. The curve drops to the normal level at about the thirty-sixth trial. The curve for group H6 (7-12) (Figure 6), on the other hand, lies below the normal

TABLE 27. INFLUENCE OF SIX DIRECTED TRIALS UPON TIME—HUMAN SUBJECTS

A.

Group	Total Time	Absolute Saving	Relative Saving (Per Cent)
H6 (1-6)	1705.75	—98.34	—6.12
H6 (7-12)	1571.79	35.62	2.22

B.

Group	Av. Time per Directed Trial	Absolute Saving	Relative Saving (Per Cent)
H6 (1-6)	136.74	—21.12	—18.27
H6 (7-12)	25.90	11.96	31.59

C.

Group	Av. Time per Trial for Trials Subsequent to Control	Absolute Saving	Relative Saving (Per Cent)
H6 (1-6)	27.27	—6.19	—29.36
H6 (7-12)	22.48	—4.56	—25.45

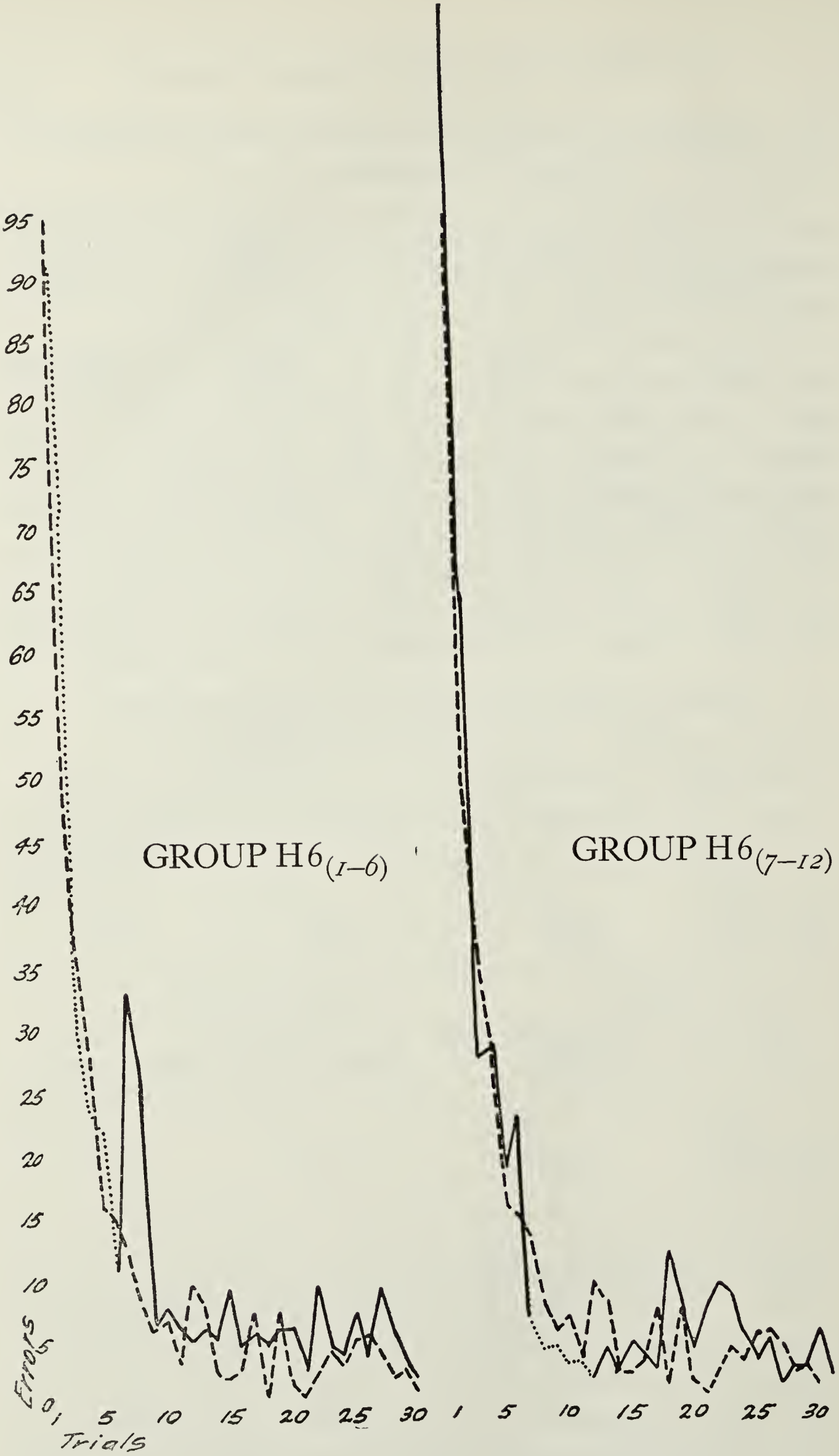

FIG. 6. A limited section of the error curve of groups H6 (1-6) and H6 (7-12) is shown superimposed upon the error curve of the unguided group. The dashes denote the unguided group; the dots, the guided trials of the guided groups; the solid line, the unguided trials of the guided groups.

in the control period and exhibits small steeples with a generally rising level in the first twelve trials of the post-control period. Like the preceding curve, it joins the normal at about the thirty-eighth trial.

Since the time scores reveal nothing very significant, we shall forego a discussion of them.

Conclusion: Six directed trials result in a small saving in both trials and total errors. The immediate effect of initial control is to increase the return errors above the normal; whereas that of interpolated control is to decrease the return errors. The subsequent effect of the guidance is to increase above the normal the time and errors per trial.

4. *Influence of Eight Directed Trials Introduced at Various Positions in the Learning Process*

Series of eight successive guided trials were introduced upon the first and upon the ninth trial.

TABLE 28. INFLUENCE OF EIGHT DIRECTED TRIALS UPON TRIALS—HUMAN SUBJECTS

Group	Trials	Absolute Saving	Relative Saving (Per Cent)
H8 (1-8)	57.4	—13.1	—29.58
H8 (9-16)	37.1	7.2	16.36

Influence upon trials (Table 28): Guidance in the initial runs increases above the normal the trials required to learn the maze, whereas control interpolated late reduces the number of trials considerably. The scores agree well with the general tendency manifested in the case of the six-trial groups, and must be accounted for upon the same principles. The tendency, on the contrary, differs radically from that observed in the case of the animals.

Influence upon errors (Table 29): Both groups exhibit a positive saving in the total number of errors made. Group H8 (9-16), although requiring fewer trials than group H8 (1-8), nevertheless ranks second in merit, when the total number of errors accumu-

TABLE 29. INFLUENCE OF EIGHT DIRECTED TRIALS UPON ERRORS—HUMAN SUBJECTS

A.

Group	Total Errors	Absolute Saving	Relative Saving (Per Cent)
H8 (1-8)	326.4	67.3	17.09
H8 (9-16)	362.7	31.0	7.87

B.

Group	Av. No. of Return Errors per Directed Trial	Absolute Saving	Relative Saving (Per Cent)
H8 (1-8)	19.76	0.00	0.00
H8 (9-16)	1.70	1.81	51.57

C.

Group	Av. No. of Cul-de-Sac Errors per Trial for Trials Subsequent to Control	Absolute Saving	Relative Saving (Per Cent)
H8 (1-8)	1.28	—.07	—5.79
H8 (9-16)	1.03	—.24	—30.38

D.

Group	Av. No. of Return Errors per Trial for Trials Subsequent to Control	Absolute Saving	Relative Saving (Per Cent)
H8 (1-8)	1.57	.03	1.88
H8 (9-16)	2.16	—.86	—66.15

lated is used as a measure. The greater efficacy of initial guidance in reducing the total number of errors was apparent, also, in the case of the six-trial series. It is, doubtless, the result largely of no subtler agency than the physical prevention of cul-de-sac errors during the extended wanderings which characterize the early runs.

The immediate influence of guidance, however, upon return

errors is relatively greater in the case of group H8 (9-16) than group H8 (1-8). Barring from consideration the fact that an increase in return errors is not exhibited by group H8 (1-8), one can note a striking resemblance in regard to the relation of the immediate effect of control granted early and late in the learning, between the six- and eight-trial series. The absence of an increase in return errors in the case of group H8 (1-8), as contrasted with group H6 (1-6), is, doubtless, the result of the interaction of a number of factors; *i.e.,* a saving in the very early trials, a loss in the few trials following these early runs (both of these we have previously described), and a saving again, perhaps, in the seventh and eighth trials, as a result of the conquest of the retracing habit. A counterbalancing of factors, rather than the absence of any influence, produces the score in return errors which exactly equals the normal.

The general effect upon the errors made per trial in the post-control period is deleterious, but only decidedly so when guidance is given late in the learning. Let it be noted that, in spite of the increase in errors, the number of trials required by group H8 (9-16) is less than that required by group H8 (1-8) or the normal group.

The curves give some interesting data upon the nature and persistence of the control's influence not revealed in the tables. For seven trials immediately following the removal of the guiding device the curve for group H8 (1-8) runs along rather regularly, considerably below the level of the normal curve. Then follows a period of large steeples extending over about nine trials, whereafter the curve descends irregularly and slightly above the normal.

This apparent occurrence of great confusion considerably after the period of control seems typical of the groups directed for long periods in the early stages of the learning, for the group guided during the initial twelve trials reveals a similar tendency (Figure 4). The phenomenon can be easily explained. Much control early in the learning builds up confidence and well established habits. The confidence is sufficient to create indifference with respect to the slight suspicions aroused by the altered cues which attend the removal of the controlling device. These suspicions grow, in the

trials that follow, because the strangeness persists. Then chance entrances into cul-de-sacs reveal a multitude of possibilities to the unsuspecting subject who seeks in them new and shorter routes to the goal. He becomes confused and almost hopelessly lost. Long after a readjustment is well afoot, waverings are apparent. Hence the reason for the irregularity of the curve in its final stages is apparent.

The curve for group H8 (9-16) in the post-control period is not very dissimilar to that of group H8 (1-8). A small steeple follows immediately the control period, then a low course is maintained for seven trials, whereupon a decided rise (larger than any previous steeple) persists for four trials. The later sections of the curve are more irregular than the normal. The disturbance is apparently not so great when guidance occurs later in the learning, as it is when control is granted in the early runs. The phenomenon is probably the result of the fact that the reagent has had some previous experience with the cul-de-sacs, knows a little concerning their fatal character, and seeks not within them, with much fervid conviction, the desired short route.

The irregularity of both curves in the post-control period reflects the persistent doubt and uncertainty resulting from the conflict of two rather well established forms of reaction.

Conclusion: Guidance extending over the initial eight trials tends to increase above the normal the number of trials and the total time required; control in the later runs reduces both trials and time. Both the initial and interpolated guidance accomplish a saving in total errors, the saving being greater in the case of initial control. The immediate effect of control is positive in the case of both time and errors, whether guidance be given early or late in the learning period, but relatively greater when control is given late. The subsequent effect of guidance is to increase above the normal the number of errors made per trial. The negative saving in errors per trial in the post-control period is greater when control is interpolated late in the trial sequence than when it occurs early.

TABLE 30. INFLUENCE OF EIGHT DIRECTED TRIALS UPON TIME—HUMAN SUBJECTS

A.

Group	Total Time	Absolute Saving	Relative Saving (Per Cent)
H8 (1-8)	1563.03	44.38	2.76
H8 (9-16)	1554.15	63.26	3.94

B.

Group	Av. Time per Directed Trial	Absolute Saving	Relative Saving (Per Cent)
H8 (1-8)	74.58	7.62	9.27
H8 (9-16)	24.31	5.68	18.94

C.

Group	Av. Time per Trial for Trials Subsequent to Control	Absolute Saving	Relative Saving (Per Cent)
H8 (1-8)	17.98	1.93	9.69
H8 (9-16)	21.21	—4.52	—27.08

SUMMARY

A. Results of Experimentation upon Animals:

1. The efficacy of a given number of guided trials is a function of their position.

2. The efficacy of the control as an agent for reducing the number of trials required to master the problem varies, as a rule, inversely as the distance of the guided series from the initial trial.

3. The influence of guidance in the realm of total errors is beneficial; but, in general, as the distance of the guided series from the initial trial increases, the total number of errors increases. When the directed series is very short, however, the intermediate position is the most favorable and it is only slightly less favorable than the initial position when the series are of medium length.

4. The immediate effect of control is to prevent cul-de-sac errors. The number prevented varies inversely as the distance of the series of directed trials from the initial run, and directly as the length of the series. The explanation of the fact harks back to the nature of the learning process.

5. The relative saving in the number of return errors amassed during the period of control which occurs in an intermediate position is always positive and, in general, greater than for any other position.

6. Short series of guided trials in the initial position increase above the normal the number of return errors made in the period of guidance, whereas the longer series in the same position result in a saving in return errors.

7. The immediate effect of control in the position most distantly removed from the beginning is not entirely unambiguous; *i.e.*, a reduction in return errors may or may not be effected. In general, however, the relative saving is less than that accomplished by control in the intermediate position.

The results indicating the immediate effect of guidance are the outcome of the interaction of factors both detrimental and advantageous. It seems well, even at the risk of accusations of prolixity, to summarize the factors suggested to account for the records made during the period of control.

The increase above the normal of the return errors amassed per trial in the shorter periods of control in the initial position, we have attempted to explain on the basis of the facilitation of complete retracings resulting from the absence of cul-de-sacs. This deleterious effect upon return errors is balanced in the longer series by the rapid attainment of a well-nigh complete mastery of the simple cul-de-sac-less maze and the consequent almost total elimination of the retracing errors in the later trials of the series. In positions other than the initial, the immediate influence of the control upon return errors is the result of a balance between the benefit derived from the prevention of cul-de-sacs, and simplification of the problem, on the one hand, and confusion or distraction attendant upon the alteration of cues already integrated into habits of various degrees of strength, on the other. The detrimental

phase of the control's influence is on the ascendency, though not always dominant, in those positions of the directed trials most distantly removed from the beginnings of the learning.

8. The saving in the number of cul-de-sac errors made per trial in the post-control period is, with one exception, positive and is, generally, greater than the saving in return errors.

9. The subsequent effect of a small amount of guidance (two or four trials) upon cul-de-sac errors is relatively greatest in the case of the groups whose period of control was introduced in an intermediate position, whereas the subsequent effect of larger amount is the most favorable when guidance occurs in the initial position.

10. The number of return errors amassed per trial in the post-control period by the groups given short periods of initial guidance or short periods of control introduced late in the learning is greater than that amassed by the normal group. The intermediate position is most favorable or least unfavorable in its subsequent effect upon return errors when the period of guidance is limited; the initial position is the most favorable when the period of control is rather extended.

The subsequent effect of control is a balance between the benefit resulting from the formation of proper habits, the prevention of the formation of undesirable reactions, the marking of the critical elements in the situation, on the one hand, and the confusion attendant upon the alteration of cues, on the other. A very limited amount of guidance in an intermediate position, when habits are plastic, merely calls attention to the critical elements of the situation and enters little into conflict with well established modes of behavior. Control interpolated late in the learning may enter into conflict with reactions to the maze that have been thoroughly ingrained.

11. Control usually results in a reduction in total time. The amount of reduction tends to vary inversely as the distance (within limits) of the directed trials from the initial run.

12. The immediate effect of guidance upon time is, in most cases, positive and is relatively greatest when control is introduced in the intermediate positions. The time per directed trial, when the

series is short and interpolated late in the learning, is greater than the normal.

13. The subsequent effect of little guidance upon the time consumed per trial is unfavorable. The intermediate position is, generally speaking, the least detrimental or the most favorable in its influence. Long periods of control tend to reduce the time per trial in the post-control period, especially when guidance occurs in the initial runs.

B. Results of the Experimentation upon Human Subjects:

1. The efficacy of a given amount of control is conditioned by the position in the learning at which it is introduced.

2. Control, if properly placed, accomplishes a reduction in the number of trials necessary for learning the maze. Generally speaking, its efficacy varies directly as its distance from the early trials. The exception to the general rule occurs in the case of short periods of initial guidance which are equal in effectiveness to periods of similar length interpolated later in the learning.

The divergence of these results from those derived in the experimentation upon animals we have accounted for largely in terms of ideational control. When the reaction to the situation has so shaped itself that the alteration of cues can be recognized with some confidence and attention can be consciously directed to the critical elements of the situation, then guidance, though causing exploration, may be effective in bringing about a rapid adjustment. The modification of the cues in the trials immediately following the first few merely counteracts the favorable aspects of the control's influence by injecting confusion into a reaction which is just losing its polymorphic character. Little guidance in the initial position is beneficial because it does prevent the formation of some unfavorable habits and is withdrawn before cues dependent upon it are integrated with any fixity into the sensory and ideational content.

3. The effect of control, measured in terms of total errors, is usually favorable and, generally speaking, varies directly with the distance of the guided trials from the initial runs. The exception to this general rule occurs in the case of very little guidance ad-

ministered rather late in the learning process. This condition is very efficacious.

4. The rapidity of adjustment may vary independently of the total number of errors accumulated.

5. The immediate effect of control is, in most cases, favorable. The relative saving in return errors effected by the longer groups of guided trials varies directly with the distance of the controlled runs from the initial trial. The reverse is true for the short series.

The saving in the number of return errors amassed during the period of control, when the directed runs are few and occur in the early trials, we have attempted to account for on the basis of the simplification in the problem which results from the absence of cul-de-sacs, as well as the improbability of complete retracings because of the barrier-like character, in the early stages of the learning, of the turns in the true pathway. Little guidance later in the learning, on the other hand, has a deleterious immediate effect because it alters cues well integrated into the individual's reactions and it is not sufficiently extended to permit an effective readjustment to the modified situation. The longer groups of directed trials, interpolated late, permit this almost complete readjustment with its resultant benefit.

A possible explanation of the increase in return errors per directed trial when the period of initial guidance is rather extended, has been hinted at in the preceding discussion. As soon as the barrier-like effect of the turns in the true pathway has been overcome —and this occurs early in the learning—control tends temporarily to facilitate retracings.

6. The subsequent effect of guidance upon cul-de-sac, as well as upon return errors, is usually detrimental, although the degree of detriment varies in no consistent way with the position of the control.

7. Control, in its subsequent effect upon errors, is not selective, as it was in the case of the animals. Its influence is as unfavorable upon cul-de-sac as upon return errors.

The subsequent effect of control we have attempted to describe as a resolution of the influences of such unfavorable factors as the distraction attendant upon the removal of the controlling de-

vice, the retracing habit established in the period of control, and voluntary explorations concomitant with elaborate analyses, on the one hand, and the effects of such favorable factors as the formation of proper habits and bringing to the attention of the subject the critical elements of the situation, on the other. The former group are usually dominant.

The assumption of a relatively analytical mode of attack on the problem by the human subjects, in contrast to the animal, seems not an unreasonable partial explanation, at least, of the differences in the behavior of the two groups. The method of distributing effort in the two experiments, moreover, may also have been no small factor in producing the variations in the results. The question needs experimental investigation.

8. The effect of control upon the total time required to master the problem is slight but usually favorable. The time scores for the period of control vary with the position of the guided trials in about the same way as do the error scores. The subsequent effect of control upon time is not sufficiently regular in its manifestations to permit a generalization.

III

THE RELATIVE EFFICACY OF VARIOUS AMOUNTS OF CONTROL

It is the purpose of this chapter to present a description and analysis of the influence upon learning of various amounts of guided effort. Although it is obviously impossible to separate entirely the influence of the amount from the influence of the position of the guidance, it seems desirable, nevertheless, to compare the behavior of those groups of animals which have had the same amount of preparation previous to the period of control.

A. Results Based upon the Records of Animal Subjects

The investigation in which animals served as subjects produced few data relevant to the topic of this chapter other than those which will furnish a basis for a consideration of the question of the relative effectiveness of various amounts of initial guidance. A comparison, however, of the influence of series of four and eight directed trials introduced upon the fifth run, is possible.

1. *The Influence of Various Amounts of Initial Guidance*

Let it be recalled that groups 2 (1-2), 4 (1-4), 6 (1-6), 8 (1-8), and 12 (1-12) were guided, respectively, for the initial 2, 4, 6, 8, or 12 trials. A consideration of the behavior of these groups will constitute the programme of this section.

Influence upon trials: Guidance in the initial position, regardless of the amount, is effective in reducing the number of trials necessary to attain a mastery of the maze (see Table 31). The efficacy of the control, however, increases as the amount of guidance is increased from two to six trials, but decreases again as the length of the guided series is extended to eight and twelve runs. In other words, there is an optimum amount of guidance beyond which the efficacy of the control decreases rapidly.

TABLE 31. INFLUENCE UPON TRIALS OF VARIOUS AMOUNTS OF GUIDANCE IN THE INITIAL POSITION—ANIMAL SUBJECTS

Group	Trials	Absolute Saving	Relative Saving (Per Cent)
2 (1-2)	25.5	8.3	24.6
4 (1-4)	22.0	11.8	34.9
6 (1-6)	15.5	18.3	54.14
8 (1-8)	19.9	13.9	41.12
12 (1-12)	24.1	9.7	28.69

Influence upon errors: The relative efficacy of various amounts of control in the initial position is the same in the realm of total errors as in the realm of trials (see Table 32). The per cent of saving increases as the number of directed trials is increased to six, and decreases slightly when more than six controlled runs are given.

The immediate effect of various amounts of guidance in the initial position upon the number of return errors made per trial we have already briefly indicated in the previous chapter. The influence of little control upon the number of return errors made per directed run is deleterious, and the degree of detriment increases as the length of the guided series is extended from two to six runs. More than six directed trials, however, effect a reduction in the number of return errors amassed per trial during the period of control.

Since the scores indicating the immediate effect of control in each series are, in part, based upon the records of all of the series shorter in length, the relative influence of each two successive trials of the first twelve runs can be demonstrated or inferred from the average scores given. Control in the first two trials is unfavorable to the reduction of return errors. This result we have attempted to explain on the basis of the facilitation of complete retracings by the prevention of cul-de-sac errors. Guidance in the third and fourth trials is relatively more unfavorable to the reduction of return errors than in the first two runs, while control in the fifth and sixth trials accomplishes the most marked relative increase in the number of retracings. Control in the seventh

TABLE 32. INFLUENCE UPON ERRORS OF VARIOUS AMOUNTS OF GUIDANCE IN THE INITIAL POSITION—ANIMAL SUBJECTS

A.

Group	Total Errors	Absolute Saving	Relative Saving (Per Cent)
2 (1-2)	143.22	16.93	10.57
4 (1-4)	99.90	60.25	37.62
6 (1-6)	69.73	90.42	56.46
8 (1-8)	71.53	88.62	55.34
12 (1-12)	81.33	78.82	49.22

B.

Group	Av. No. of Return Errors per Directed Trial	Absolute Saving	Relative Saving (Per Cent)
2 (1-2)	22.11	—1.00	—4.74
4 (1-4)	14.54	—1.57	—12.10
6 (1-6)	10.87	—2.05	—23.24
8 (1-8)	5.84	1.08	15.67
12 (1-12)	3.28	1.34	29.00

C.

Group	Av. No. of Cul-de-sac Errors per Trial for Trials Subsequent to Control	Absolute Saving	Relative Saving (Per Cent)
2 (1-2)	2.12	—.14	—7.07
4 (1-4)	1.46	.85	36.79
6 (1-6)	.43	1.32	75.43
8 (1-8)	.45	1.16	72.05
12 (1-12)	.67	.62	48.06

D.

Group	Av. No. of Return Errors per Trial for Trials Subsequent to Control	Absolute Saving	Relative Saving (Per Cent)
2 (1-2)	2.00	—.88	—85.98
4 (1-4)	1.03	—.29	—39.18
6 (1-6)	.60	.28	31.82
8 (1-8)	.30	.43	58.90
12 (1-12)	.74	—.23	—45.09

and eighth trials—trials in which rapid progress is being made in the mastery of the simple cul-de-sac-less maze—effects a decrease in return errors which is sufficiently great to counterbalance the negative effects of control in the earlier trials and to produce, as a final result, an actual saving in the average number of return errors amassed per directed trial. Guidance from the eighth to the twelfth trial is, likewise, very effective in reducing the return errors made per controlled run.

The subsequent effect of control (Table 32) in the realm of cul-de-sac errors is, in general, to produce a diminution in the number amassed per trial. Group 2 (1-2) is an exception to this rule. The subsequent effect of the control upon cul-de-sac errors becomes beneficial and increasingly so, as the length of the guided series is increased to six trials, but the relative saving decreases slightly as the control is extended to eight and twelve runs. The same general relation between the amount of control and the number of cul-de-sac errors made per trial obtains, if we consider merely the cul-de-sac errors made by each of the groups in the trials following the twelfth.

A deleterious effect on the part of the control upon the return errors amassed per trial in the post-control period is apparent in the groups guided for two, four and twelve trials; six and eight directed trials, however, reduce the retracings. It is significant that, in each of the five cases, the relative benefit is greater, or the relative detriment less, in the realm of cul-de-sac than in the realm of return errors.

The probable factors determining the error and trial scores just described have been frequently indicated. In the diffuse reaction characteristic of the first few trials, guidance can do little to establish a tendency to follow the true pathway; yet it does encourage the formation of the retracing habit. When the cul-de-sacs are opened, after the short period of control, the animal that has a tendency to retrace, will be given plenty of opportunities to be enticed into the pitfalls. The unfavorable effects, then, of short series of directed trials introduced at the beginning of the learning process may be greater than those of series of intermediate lengths. The retracing habit, when the controlled series of trials is of inter-

mediate length, tends to decline in the later runs of the period of guidance, and proper habits are established. The reaction, moreover, at the time the control is removed is sufficiently plastic to suffer no great disruption by the alteration of some of the cues. The longer series, on the other hand, permit habits of considerable stability to develop. Alteration of cues is more likely to be disrupting under these circumstances than in the less extended series. Hence the reason for the relative superiority of series of medium length is apparent.

TABLE 33. INFLUENCE UPON TIME OF VARIOUS AMOUNTS OF GUIDANCE IN THE INITIAL POSITION—ANIMAL SUBJECTS

A.

Group	Total Time	Absolute Saving	Relative Saving (Per Cent)
2 (1-2)	1389.86	360.86	20.61
4 (1-4)	1298.97	451.75	25.80
6 (1-6)	1079.61	671.11	38.33
8 (1-8)	1076.73	673.99	38.50
12 (1-12)	1193.23	557.49	32.99

B.

Group	Av. Time per Directed Trial	Absolute Saving	Relative Saving (Per Cent)
2 (1-2)	367.82	142.69	27.95
4 (1-4)	234.87	76.59	24.59
6 (1-6)	174.59	2.10	1.19
8 (1-8)	88.60	16.57	15.76
12 (1-12)	55.79	53.82	49.10

C.

Group	Av. Time per Trial for Trials Subsequent to Control	Absolute Saving	Relative Saving (Per Cent)
2 (1-2)	33.56	—11.72	—53.66
4 (1-4)	30.99	—9.62	—45.01
6 (1-6)	18.24	1.78	8.89
8 (1-8)	13.72	5.03	26.83
12 (1-12)	16.64	1.39	7.71

Influence upon time (Table 33) : A discussion of the influence of initial guidance upon time will be omitted, since the time scores exhibit, in general, the same tendencies revealed in the error scores.

2. *Influence of Various Amounts of Guidance Introduced Upon the Fifth Trial*

The discussion of this section must be limited to a consideration of the effect of four and eight guided trials upon learning. Since the number of cases in each group is small, and since the data derived under only two different conditions are being compared, no great reliance can be placed on the results.

TABLE 34. INFLUENCE UPON TRIALS OF VARIOUS AMOUNTS OF GUIDANCE INTRODUCED UPON THE FIFTH TRIAL—ANIMAL SUBJECTS

Group	Trials	Absolute Saving	Relative Saving (Per Cent)
4 (5-8)	28.1	5.7	16.90
8 (5-12)	26.8	7.0	20.71

Influence upon trials (Table 34) : Eight directed runs introduced upon the fifth trial are slightly more effective in reducing the number of trials required to attain a mastery of the maze, than are four controlled runs.

Influence upon error (Table 35) : From the point of view of the total number of errors amassed during the learning, four and eight guided trials are equally efficacious. This is significant, since the greater amount of control does result in a slight saving in trials. The result is attributable largely to the immediate effect of the guidance. The longer period of control accomplishes an increase in the number of return errors amassed per directed run, whereas the shorter does not. This relation is an anomaly for which the writer can offer no explanation except that of chance. One would expect, since the first four of the series of eight controlled trials exhibit a reduction in return errors, that four trials more of practice under unaltered conditions would produce a relative saving,

TABLE 35. INFLUENCE UPON ERRORS OF VARIOUS AMOUNTS OF GUIDANCE INTRODUCED UPON THE FIFTH TRIAL—ANIMAL SUBJECTS

A.

Group	Total Errors	Absolute Saving	Relative Saving (Per Cent)
4 (5-8)	107.71	52.44	32.74
8 (5-12)	107.71	52.44	32.74

B.

Group	Av. No. of Return Errors per Directed Trial	Absolute Saving	Relative Saving (Per Cent)
4 (5-8)	2.89	.11	3.67
8 (5-12)	2.43	—.23	—10.45

C.

Group	Av. No. of Cul-de-sac Errors per Trial for Trials Subsequent to Control	Absolute Saving	Relative Saving (Per Cent)
4 (5-8)	1.01	.60	37.27
8 (5-12)	.70	.59	45.73

D.

Group	Av. No. of Return Errors per Trial for Trials Subsequent to Control	Absolute Saving	Relative Saving (Per Cent)
4 (5-8)	.57	.16	21.92
8 (5-12)	.50	.01	1.99

at least equal to that accomplished in the first four trials, if not greater.

The scores indicating the subsequent effect of control reveal that the longer period of control has a greater beneficial effect upon cul-de-sac errors than does the shorter, and that the reverse is true for the return errors. The same relation between the error scores of the two groups holds, if the performance in the trials beyond

the twelfth is considered. Evidently, then, any distraction attendant upon the alteration of cues which have had opportunity in the eight guided trials to become well integrated into the reaction, manifests itself largely in the realm of return errors. It is, also, probable that the persistence of the retracing habit established during the period of control is responsible for the small saving in return errors in the post-control period exhibited by group 8 (5-12), as contrasted with the saving manifested by group 4 (5-8).

TABLE 36. INFLUENCE UPON TIME OF VARIOUS AMOUNTS OF GUIDANCE INTRODUCED UPON THE FIFTH TRIAL—ANIMAL SUBJECTS

A.

Group	Total Time	Absolute Saving	Relative Saving (Per Cent)
4 (5-8)	1547.30	203.42	11.61
8 (5-12)	1476.37	274.35	15.67

B.

Group	Av. Time per Directed Trial	Absolute Saving	Relative Saving (Per Cent)
4 (5-8)	33.96	13.87	29.00
8 (5-12)	25.85	6.46	19.99

C.

Group	Av. Time per Trial for Trials Subsequent to Control	Absolute Saving	Relative Saving (Per Cent)
4 (5-8)	18.45	.30	1.60
8 (5-12)	14.32	3.71	20.58

Influence upon time (Table 36) : The time scores indicate little that is not predictable from the scores in trials and errors. The saving in total time is slightly greater when more guidance is given than when the control is very limited. The average time per directed trial is less than the normal, but group 4 (5-8), contrary

to expectation, exhibits a greater relative saving than does group 8 (5-12). The relative saving in time per trial for the trials of the post-control period is greater for group 8 (5-12) than for group 4 (5-8). Apparently the greater distraction attendant upon the removal of the controlling device after the longer period of guidance is overbalanced by the increased facility in running resulting from the four extra directed trials given group 8 (5-12), as opposed to group 4 (5-8).

B. Results Based upon the Records of Human Subjects

1. *Influence of Various Amounts of Initial Guidance*

The groups of subjects whose records will furnish the data for the discussion of this section were guided for the initial 2, 4, 6, 8 or 12 trials.

TABLE 37. INFLUENCE UPON TRIALS OF VARIOUS AMOUNTS OF GUIDANCE IN THE INITIAL POSITION—HUMAN SUBJECTS

Group	Trials	Absolute Saving	Relative Saving (Per Cent)
H2 (1-2)	36.9	7.4	16.70
H4 (1-4)	37.1	7.2	16.26
H6 (1-6)	43.6	.7	1.58
H8 (1-8)	57.4	—13.1	—36.09
H12(1-12)	45.7	—1.4	—3.16

Influence upon trials (Table 37) : The effect upon learning, in the case of the human subjects, of groups of controlled trials of various lengths, when the period of guidance has not been preceded by any training, diverges greatly from that noted in the case of the animals. The efficacy of the control, from the point of view of its capacity to decrease the number of trials required by the human subjects to attain a mastery of the maze, varies, generally speaking, inversely as the length of the group of controlled runs. Eight and twelve directed runs even effect an increase above the normal in the number of trials needed for learning the problem. Whether the greater increase in trials exhibited by group

H8 (1-8), in contrast to group H12 (1-12), is a fair index of what would happen, were a much larger number of individuals considered, is a question. If the tendency indicated is representative, then we may say that the efficacy of the control decreases as the control is increased to a certain amount. If more guidance is given, however, the influence of control becomes less detrimental. Such a condition seems not at all improbable, in the light of the general tendencies observed in the error scores.

Influence upon errors (Table 38) : The influence of guidance in the initial position upon the total number of errors amassed is favorable, for a considerable reduction in errors is exhibited by each of the five groups under consideration. Short and long periods of guidance are most effective, however. It is significant that this result is diametrically opposite to that obtained in the experiment upon animals. The reduction in the total number of errors made by the groups guided for the longer periods is apparently the result of the prevention of the cul-de-sac errors by the controlling device, since the error scores for the post-control period, as well as the return error scores, for the period of guidance, and the trials scores are all higher than the normal.

The immediate influence of guidance upon return errors is favorable when the period of control is short; detrimental, when it is longer. In general, then, the efficacy of the directed runs varies inversely as their number. Group H8 (1-8) is slightly aberrant. The divergence of the results indicating the immediate effect of guidance from those exhibited in the animal records we have already attempted to explain in terms of the barrier-like function in the very early trials of the turns of the true pathway, with the consequent prevention, to a large degree, of retracings of any length. As soon as the subject is slightly familiar with the pathway, his behavior, so far as return errors are concerned, resembles that of the animals in the first few trials.

The third and fourth trials are less effective in preventing return errors than are the first two. In the fifth and sixth guided trials the return errors are greatly increased above the normal; in the seventh and eighth trials, they are again much reduced. It is possible, perhaps even probable, as previously suggested, that by the seventh

TABLE 38. INFLUENCE UPON ERRORS OF VARIOUS AMOUNTS OF GUIDANCE IN THE INITIAL POSITION—HUMAN SUBJECTS

A.

Group	Total Errors	Absolute Saving	Relative Saving (Per Cent)
H2 (1-2)	289.5	104.2	26.47
H4 (1-4)	255.0	138.7	35.23
H6 (1-6)	334.8	58.9	14.96
H8 (1-8)	326.4	67.3	17.09
H12(1-12)	293.6	100.1	25.43

B.

Group	Av. No. of Return Errors per Directed Trial	Absolute Saving	Relative Saving (Per Cent)
H2 (1-2)	39.15	17.20	30.53
H4 (1-4)	33.55	4.36	11.50
H6 (1-6)	30.52	—3.76	—12.32
H8 (1-8)	19.76	0.00	0.00
H12(1-12)	14.93	—1.79	—11.99

C.

Group	Av. No. of Cul-de-sac Errors per Trial for Trials Subsequent to Control	Absolute Saving	Relative Saving (Per Cent)
H2 (1-2)	2.19	—.46	—26.59
H4 (1-4)	1.38	.16	10.31
H6 (1-6)	1.75	—.44	—33.59
H8 (1-8)	1.28	—.07	—5.79
H12(1-12)	1.37	—.39	—39.80

D.

Group	Av. No. of Return Errors per Trial for Trials Subsequent to Control	Absolute Saving	Relative Saving (Per Cent)
H2 (1-2)	3.39	—.51	—17.71
H4 (1-4)	1.80	.60	25.00
H6 (1-6)	3.53	—1.68	—90.81
H8 (1-8)	1.57	.03	1.88
H12(1-12)	2.03	—.69	—51.49

and eighth trials in a series of guided runs the subject has sufficiently mastered the true pathway to have eliminated, in large measure, the retracing habit. At any rate, the saving in return errors exhibited in the seventh and eighth trials is sufficient to balance, when the average return error per trial for the first eight trials is considered, the unfavorable effect of the fifth and sixth runs.

Should we accept the explanation just offered for the favorable influence of the seventh and eighth directed trials, we have the problem of the unfavorable influence of the ninth to the twelfth trials to consider. This we have suggested may be the result of explorations on the part of some of the subjects who, as soon as they feel themselves well oriented, set up as their next problem the detecting of some more obscure or hidden short route, rather than the tedious perfecting of a well-nigh perfect habit. The remarks of the subjects give the writer some faith in this interpretation of the results.

The subsequent effect of control upon the average number of cul-de-sac or return errors amassed per trial shows no consistent variation with the length of the period of guidance. If, however, we consider the average number of cul-de-sac errors made per trial by each of the groups in the trials after the sixteenth, a more consistent variation with amount of control is apparent. The influence upon the cul-de-sac errors is, in each case, unfavorable; but the degree of unfavorableness varies directly as the amount of guidance. The return error scores for the trials subsequent to the sixteenth show no such regular variation with the amount of control administered.

Influence upon time (Table 39) : The scores indicating the total time required to master the problem manifest, with one exception, small savings upon the normal. They exhibit, however, the same general pattern, as far as their relation to amount of control is concerned, as do the error scores.

The immediate effect is positive and greatest for the shortest and longest control periods. The large saving manifested in the trials from the ninth to the twelfth is significant, because in these trials we have an increase or, at least, no decrease in the return

TABLE 39. INFLUENCE UPON TIME OF VARIOUS AMOUNTS OF GUIDANCE IN THE INITIAL POSITION— HUMAN SUBJECTS

A.

Group	Total Time	Absolute Saving	Relative Saving (Per Cent)
H2 (1-2)	1573.69	33.72	2.10
H4 (1-4)	1548.63	58.78	3.66
H6 (1-6)	1705.75	—98.34	—6.12
H8 (1-8)	1563.03	44.38	2.76
H12(1-12)	1426.78	180.63	11.24

B.

Group	Av.Time per Directed Trial	Absolute Saving	Relative Saving (Per Cent)
H2 (1-2)	199.85	50.40	20.14
H4 (1-4)	149.92	17.60	10.50
H6 (1-6)	136.74	—21.12	—18.27
H8 (1-8)	74.58	7.62	9.27
H12(1-12)	61.71	12.97	17.37

C.

Group	Av. Time per Trial for Trials Subsequent to Control	Absolute Saving	Relative Saving (Per Cent)
H2 (1-2)	35.84	—11.04	—44.52
H4 (1-4)	28.55	—5.55	—24.13
H6 (1-6)	27.27	—6.19	—29.36
H8 (1-8)	17.98	1.93	9.69
H12(1-12)	19.52	—1.60	—8.92

errors. Though returns may be increased, time is saved because of the prevention of cul-de-sac errors.

The time per trial in the post-control period is increased, generally speaking, but the relative increase becomes less as the length of the guided series increases. This relation between time and amount of guidance may be a direct result of the influence of the control upon the time or it may be a result of the increased number of trials and the consequent facility in traversing the maze acquired with increased practice. The latter hypothesis seems very

reasonable because the amount of loss in the time required per trial correlates well with the number of trials taken to master the maze.

2. *Influence of Various Amounts of Guidance Introduced upon the Fifth Trial*

Series of guided trials two and four runs in length were introduced upon the fifth trial.

TABLE 40. INFLUENCE UPON TRIALS OF VARIOUS AMOUNTS OF GUIDANCE INTRODUCED UPON THE FIFTH TRIAL—HUMAN SUBJECTS

Group	Trials	Absolute Saving	Relative Saving (Per Cent)
H2 (5-6)	43.0	1.3	2.93
H4 (5-8)	43.7	.6	1.36

Influence upon trials (Table 40) : Two and four directed runs interpolated at this critical intermediate stage of the learning are scarcely efficacious in reducing the number of trials required to master the maze. Considering, moreover, the variability in the trial scores, we do not seem justified in attempting an evaluation of the relative effectiveness of the two series.

Influence upon errors (Table 41) : The relative efficacy of the two series of guided trials is, perhaps, more apparent in the realm of total errors. Control extending over two trials increases the total number of errors amassed before a mastery of the problem is attained, whereas four directed trials slightly reduce the number of errors.

The immediate effect of the guidance upon return errors is favorable in the case of both of the groups, although the absolute, as well as the relative, saving is greater for the group controlled for only two trials. This relation between the scores of the two groups is scarcely to be expected. It may, however, be accounted for in much the same way as the similar relation between the scores of the groups guided for the initial two and four trials. The turns in the true pathway may still have in the fifth and sixth,

TABLE 41. INFLUENCE UPON ERRORS OF VARIOUS AMOUNTS OF GUIDANCE INTRODUCED UPON THE FIFTH TRIAL—HUMAN SUBJECTS

A.

Group	Total Errors	Absolute Saving	Relative Saving (Per Cent)
H2 (5-6)	427.6	—33.9	—8.61
H4 (5-8)	378.5	15.2	3.86

B.

Group	Av. No. of Return Errors per Directed Trial	Absolute Saving	Relative Saving (Per Cent)
H2 (5-6)	9.68	1.94	16.84
H4 (5-8)	8.30	.67	7.47

C.

Group	Av. No. of Cul-de-sac Errors per Trial for Trials Subsequent to Control	Absolute Saving	Relative Saving (Per Cent)
H2 (5-6)	1.67	—.36	—27.48
H4 (5-8)	1.68	—.47	—38.84

D.

Group	Av. No. of Return Errors per Trial for Trials Subsequent to Control	Absolute Saving	Relative Saving (Per Cent)
H2 (5-6)	2.74	—.89	—48.11
H4 (5-8)	1.84	—.24	—15.00

as a result of the uncertainty produced by the alteration of cues, a sufficiently barrier-like action to prevent long retracings, whereas in the seventh and eighth runs increasing familiarity with the true pathway may tend to favor longer returns and, consequently, to produce a relatively higher error score.

The effect of the control upon the number of errors made per trial in the post-control period is decidedly deleterious. The short

series of directed runs has a more unfavorable effect upon return errors than upon cul-de-sac errors, while the reverse is true for the group guided for a longer time. Since in the case of the human subjects, four trials in this intermediate position is a sufficiently long period to permit the subject to develop some conscious dependence upon the cues from the controlling device, and since, moreover, the subject is not informed of the removal of the control, one might expect the abstraction of the guiding cues to instigate a search for the lost cues on the part of the subject and hence increase, to a relatively greater degree than would the two directed trials, the number of cul-de-sac errors amassed per trial in the post-control period. The result, on the other hand, may be a mere matter of chance.

Influence upon time (Table 42): Since the time scores reveal nothing significant, they will not be discussed.

TABLE 42. INFLUENCE UPON TIME OF VARIOUS AMOUNTS OF GUIDANCE INTRODUCED UPON THE FIFTH TRIAL—HUMAN SUBJECTS

A.

Group	Total Time	Absolute Saving	Relative Saving (Per Cent)
H2 (5-6)	1759.48	—152.07	—9.46
H4 (5-8)	1597.22	10.19	.63

B.

Group	Av. Time per Directed Trial	Absolute Saving	Relative Saving (Per Cent)
H2 (5-6)	49.07	2.92	5.61
H4 (5-8)	42.17	3.63	7.09

C.

Group	Av. Time per Trial for Trials Subsequent to Control	Absolute Saving	Relative Saving (Per Cent)
H2 (5-6)	27.79	—6.71	—31.83
H4 (5-8)	22.90	—2.99	—15.02

3. *Influence of Various Amounts of Guidance Introduced upon the Seventh Trial*

The influence of a series of two and six directed trials introduced upon the seventh run will furnish the material for the discussion of this section.

TABLE 43. INFLUENCE UPON TRIALS OF VARIOUS AMOUNTS OF GUIDANCE INTRODUCED UPON THE SEVENTH TRIAL—HUMAN SUBJECTS

Group	Trials	Absolute Saving	Relative Saving (Per Cent)
H2 (7-8)	41.1	3.2	7.22
H6 (7-12)	37.1	7.2	16.24

Influence upon trials (Table 43) : Contrary to the findings up to this point, the longer of the two series reduces more markedly than the shorter the number of trials required to master the maze. Because of the small number of cases in each group, and because of our failure to provide a series of groups whose periods of guidance shall form a series of gradually increasing length, the results cannot be taken too seriously.

Influence upon errors (Table 44) : The influence of two and six guided runs upon the total error scores is very slight. The two series of directed runs are about equally efficacious, when efficacy is measured in terms of the total number of errors made; but the manner in which the two series influence errors is very different. The immediate effect of the two-trial series upon return errors is decidedly unfavorable, whereas that of the six-trial series is markedly favorable. In the post-control period, on the other hand, while all error scores are increased above the normal in both of the groups, the longer series of controlled runs has a relatively more unfavorable effect upon cul-de-sac errors than does the short series. The reverse is true in the realm of return errors.

TABLE 44. INFLUENCE UPON ERRORS OF VARIOUS AMOUNTS OF GUIDANCE INTRODUCED UPON THE SEVENTH TRIAL—HUMAN SUBJECTS

A.

Group	Total Errors	Absolute Saving	Relative Saving (Per Cent)
H2 (7-8)	378.3	15.4	3.91
H6 (7-12)	380.3	13.4	3.40

B.

Group	Av. No. of Return Errors per Directed Trial	Absolute Saving	Relative Saving (Per Cent)
H2 (7-8)	8.72	—1.94	—28.61
H6 (7-12)	3.95	1.35	25.61

C.

Group	Av. No. of Cul-de-sac Errors per Trial for Trials Subsequent to Control	Absolute Saving	Relative Saving (Per Cent)
H2 (7-8)	1.29	—.08	—6.61
H6 (7-12)	1.16	—.18	—18.36

D.

Group	Av. No. of Return Errors per Trial for Trials Subsequent to Control	Absolute Saving	Relative Saving (Per Cent)
H2 (7-8)	2.06	—.46	—28.75
H6 (7-12)	1.45	—.11	—8.21

TABLE 45. INFLUENCE UPON TIME OF VARIOUS AMOUNTS OF GUIDANCE INTRODUCED UPON THE SEVENTH TRIAL—HUMAN SUBJECTS

A.

Group	Total Time	Absolute Saving	Relative Saving (Per Cent)
H2 (7-8)	1587.92	19.49	1.21
H6 (7-12)	1571.79	35.62	2.22

B.

Group	Av. Time per Directed Trial	Absolute Saving	Relative Saving (Per Cent)
H2 (7-8)	38.42	2.52	6.22
H6 (7-12)	25.90	11.96	31.59

C.

Group	Av. Time per Trial for Trials Subsequent to Control	Absolute Saving	Relative Saving (Per Cent)
H2 (7-8)	19.22	.69	3.46
H6 (7-12)	22.48	—4.56	—25.45

Influence upon time (Table 45): The influence of each of the two series of directed runs upon the total time required to effect a mastery of the problem is practically negligible. This result is the outcome, however, of two or more antagonistic effects, rather than a lack of influence on the part of the control. The immediate effect of the longer series is markedly beneficial; its subsequent effect is decidedly detrimental. The short series, on the other hand, produces a slight saving in the time consumed per trial in both the control and post-control periods. The increase in time per trial for the trials of the post-control period exhibited by group H6 (7-12) may have little significance as an index of the influence of the control upon time, for this group displays a not inconsiderable saving in trials. Saving in trials, as we have so often indicated, operates to increase the time per trial above the normal through decreasing the practice an animal gets in running the maze.

4. *Influence of Various Amounts of Control Introduced upon the Ninth Trial*

The experiment was so arranged that series of two, four and eight directed trials were introduced upon the ninth run. The group guided for two runs we have referred to as H2 (9-10); that guided for four trials, as H4 (9-12); and the group controlled for eight trials, as H8 (9-16).

TABLE 46. INFLUENCE UPON TRIALS OF VARIOUS AMOUNTS OF GUIDANCE INTRODUCED UPON THE NINTH TRIAL—HUMAN SUBJECTS

Group	Trials	Absolute Saving	Relative Saving (Per Cent)
H2 (9-10)	35.6	8.7	19.04
H4 (9-12)	37.5	6.8	15.35
H8 (9-16)	37.1	7.2	16.36

Influence upon trials (Table 46): Two, four and eight directed runs all operate to produce a reduction in the number of trials required to master the problem. No direct variation of the amount of benefit with the amount of control administered is apparent, however. Very little control seems slightly more beneficial than a great deal. Control in medium amounts is, on the other hand, less efficacious than more generous quantities.

A series of two directed trials probably operates to call attention to the critical elements of the situation, to suggest new possibilities without disrupting, to any degree, the old procedure. The four-trial series is, doubtless, sufficiently extended to indicate vaguely the proper method of procedure to the subject, and not sufficiently long to define it clearly. Removal of the control, then, is very likely to be disrupting because it initiates explorations aimed at the recovery of cues which are not again to be found. When the period of control is sufficiently extended, it permits the development of a rather clear definition of the situation and gives to the subject confidence in his conception of the proper path. The removal of the controlling device tends to be recognized as an alteration of the maze pattern which, the subject infers, has been

brought about by the experimenter. Hence he is not very much perturbed by the modification.

Influence upon errors (Table 47): The hypothesis just advanced is supported by both the error and time scores. Two and eight directed runs produce a saving in the total number of errors made; four controlled trials, on the other hand, are detrimental, so far as their effect upon total errors is concerned.

The number of return errors made per guided trial varies inversely as the number of the trials in the series. The immediate influence of the two and four-trial series is detrimental; eight controlled runs, on the other hand, effect, as an immediate result, a relatively large saving in return errors.

The introduction of the control and the consequent alteration of the cues in the ninth trial, when habits have become well established, is confusing. This confusion would naturally be at its maximum in the first two trials of the controlled series. By the third and fourth trials of the guided series the confusion has, to a large extent, disappeared and the total number of return errors made is reduced below the normal, but not sufficiently to counterbalance, when the average of the first four trials is taken, the increase in the return errors apparent in the first two trials. The fifth to the eighth trials of the guided series are characterized by a marked reduction below the normal of the return errors amassed per trial. This condition indicates that the absence of cul-de-sacs, after the subject becomes adapted to the altered situation, does operate to decrease the number of return errors that are made.

The subsequent effect of the guided series upon both the return and cul-de-sac errors amassed per trial in all three of the groups is unfavorable. The relative increase in the number of errors made per trial in the post-control period is least in the case of the group guided for two runs and greatest in the case of that group given four directed trials. One would expect that the more fixed the habit, *i.e.*, the longer the period of control, the more confusing the removal of the guiding device would be, but, as we have previously indicated, there is a possibility of emotional and ideational factors arising to favor slightly the long period of control as opposed to that of intermediate length.

TABLE 47. INFLUENCE UPON ERRORS OF VARIOUS AMOUNTS OF GUIDANCE INTRODUCED UPON THE NINTH TRIAL—HUMAN SUBJECTS

A.

Group	Total Errors	Absolute Saving	Relative Saving (Per Cent)
H2 (9-10)	367.8	25.9	6.58
H4 (9-12)	417.6	—23.9	—6.07
H8 (9-16)	362.7	31.0	7.87

B.

Group	Av. No. of Return Errors per Directed Trial	Absolute Saving	Relative Saving (Per Cent)
H2 (9-10)	9.57	—5.82	—155.20
H4 (9-12)	5.81	—1.06	—22.23
H8 (9-16)	1.70	1.81	51.57

C.

Group	Av. No. of Cul-de-sac Errors per Trial for Trials Subsequent to Control	Absolute Saving	Relative Saving (Per Cent)
H2 (9-10)	1.36	—.18	—15.25
H4 (9-12)	1.63	—.65	—66.32
H8 (9-16)	1.03	—.24	—30.38

D.

Group	Av. No. of Return Errors per Trial for Trials Subsequent to Control	Absolute Saving	Relative Saving (Per Cent)
H2 (9-10)	1.75	—.41	—30.59
H4 (9-12)	2.92	—1.58	—117.91
H8 (9-16)	2.16	—.86	—66.15

Influence upon time (Table 48): The time scores reveal few tendencies that are not apparent in the error scores. Group H2 (9-10) exhibits a considerably greater saving in the total time consumed in the learning of the maze, as contrasted with

TABLE 48. INFLUENCE UPON TIME OF VARIOUS AMOUNTS OF GUIDANCE INTRODUCED UPON THE NINTH TRIAL—HUMAN SUBJECTS

A.

Group	Total Time	Absolute Saving	Relative Saving (Per Cent)
H2 (9-10)	1389.19	218.22	13.57
H4 (9-12)	1566.48	40.93	2.57
H8 (9-16)	1554.15	63.26	3.94

B.

Group	Av. Time per Directed Trial	Absolute Saving	Relative Saving (Per Cent)
H2 (9-10)	41.07	—9.42	—29.76
H4 (9-12)	32.73	3.46	9.57
H8 (9-16)	24.31	5.68	18.94

C.

Group	Av. Time per Trial For Trials Subsequent to Control	Absolute Saving	Relative Saving (Per Cent)
H2 (9-10)	20.43	—1.63	—8.67
H4 (9-12)	21.77	—3.85	—21.48
H8 (9-16)	21.21	—4.52	—27.08

groups H4 (9-12) and H8 (9-16), than the error scores would lead one to suspect. The relative increase, furthermore, in the time required per trial in the post-control period varies directly as the amount of guidance granted. This tendency is also somewhat surprising in view of the error scores. The results are not out of keeping, however, with the hypothesis set forth in the previous paragraph. One would expect the individual who rather clearly recognizes the alteration of the maze when the controlling device is removed and believes, perhaps, that he is being tricked, to be slow and deliberate in his movements.

SUMMARY

A. Results of Experimentation upon Animals:

1. The efficacy of control is a function of the amount administered.

2. When guidance is given in the early trials, its efficacy increases as the number of directed runs is increased up to a certain optimum number. If the length of the guided series is further extended, the efficacy of the control decreases. This tendency is manifested in the scores indicating the trials required, the total errors made, and the total time consumed, as well as the errors made per trial and time required per trial in the post-control period.

The optimum amount of guidance is probably that which permits a fairly clearly defined habit to develop, but terminates when the habit is still sufficiently plastic to allow a ready substitution of new cues as stimuli for the proper responses.

3. In the early trials of a controlled series the immediate influence of guidance upon the number of return errors made per trial is unfavorable. In the later trials of the series, however, the prevention of cul-de-sacs operates to reduce far below the normal the number of retracings.

The probable explanation for this fact has been indicated in the body of the present chapter, as well as in the summary of the preceding.

4. Of four and eight directed trials interpolated upon the fifth run, eight trials are, in general, the more efficacious. The immediate effect of the four-trial series upon the time consumed per trial, and the immediate, as well as subsequent, effect of the same series upon the number of return errors amassed per trial, is, however, more favorable than that of the eight-trial series. No great reliance, however, can be placed upon these results.

B. Results of Experimentation upon Human Subjects:

1. The efficacy of control varies with the amount administered.

2. The relative effectiveness of various amounts of guidance is a function of the position in the learning process at which the control is interpolated.

3. In the early and late stages of the learning, the very short or very long periods of the control are more efficacious than the periods of medium length. This relation is apparent when efficacy is measured in terms of the number of trials required or the total errors made or the total time consumed. The control period must either be so short that it merely calls attention in a vague way to the critical elements of the situation without markedly disrupting the old procedure, or so long that it permits the development of a rather clear conception of the true pathway and an attendant confidence.

4. Upon the relative efficacy of various amounts of control interpolated in an intermediate position in the sequence of trials, no generalization can be made.

5. When guidance is given in the early stages of the learning, its immediate effect upon return errors is favorable, if the period of control is short; unfavorable, if the period of control is long. The reverse is true, when the series of controlled trials is interpolated later in the learning.

The probable explanation of the relation between the number of return errors made per directed trial to the length of the period of control, when the guidance is given in the early stages of the learning, has been indicated in the summary of the preceding chapter.

When the directed trials are interpolated later in the learning, the alteration of cues attendant upon the introduction of the controlling device causes confusion and much retracing. This confusion is easily overcome if the period of control is extended; and then the absence of cul-de-sacs favors a rapid mastery of the simple pathway with a consequent marked reduction in the return errors.

6. No generalization can be made concerning the relative subsequent effect upon errors of various amounts of control.

7. When the guidance occurs at any but the earliest period of the learning, the saving in time per directed trial varies directly with the amount of control given. The reverse relation holds between the time consumed per trial in the post-control period and the amount of guidance.

8. In the case of guided series occurring very early in the trial sequence, the immediate effect of little or much control upon the average time required per trial is favorable; that of a medium amount, unfavorable. The subsequent effect upon the time required per trial of various amounts of control in the initial position is, generally speaking, deleterious. The degree to which the time per trial is increased above the normal varies inversely with the amount of control. This latter relation may be an indirect result of the influence of control upon trials, rather than the direct outcome of its action upon time. In the degree to which control reduces the number of trials required, it decreases the length of the practice period, and hence, perhaps, the general facility with which the problem is handled.

9. The results obtained in the experiment upon human and animal subjects are in most respects opposite. The divergence may be a consequence of the species difference, a difference in the distribution of the effort, or some other unavoidable variation in the procedure of the two experiments. The reason for the difference needs further investigation.

IV

THE INFLUENCE OF CONTROL UPON RETENTION

It has been a popular belief that responses developed by one's own unaided efforts are more thoroughly integrated into his action systems than those developed under guidance; that what one learns without aid, he retains best. The doctrine has accumulated considerable weight because of its relation to certain moral principles, as well as because of the absence of any definite contradictory evidence. No experimental studies which would cast light upon the validity of the belief have been reported. Hence our investigation of the problem, though neither elaborate nor extensive, should have at least suggestive value.

Our inquiry was limited merely to a consideration of the influence of guidance upon the retention of a motor habit by human subjects. Retention, moreover, was measured in terms of the number of errors made and the time consumed in a single tracing of the maze forty-eight hours after the problem had been mastered. No attempt was made to trace the influence of guidance upon the course of the disintegration of the habit.

The results (see Tables 49 and 50) of our investigation indicate that guidance does influence the retention of a motor habit. Under certain conditions the effect of control is favorable; under others, detrimental. The efficacy of the directed runs is determined, in part at least, by the number employed and the position at which they are interpolated in the learning period. It is evident from Table 49 that the accuracy with which the habit functions after a lapse of forty-eight hours varies, generally speaking, inversely as the distance of the period of guidance from the beginning of the learning. Control interpolated in the early stages of the learning period tends to decrease below the normal the number of errors made in the retention test, whereas guidance given in the trials subsequent to the sixth is unfavorable in its influence upon error. No very consistent relation, on the other hand, is apparent be-

tween the time consumed in the test for retention and the position in the learning at which the guided effort occurs.

TABLE 49. TOTAL NUMBER OF ERRORS MADE IN THE RETENTION TEST

No. of Directed Trials in the Learning Period	Trial upon Which the Controlled Series is Introduced					
	1	3	5	7	9	11
2	1.0	2.7	2.4	4.3	5.1	4.8
4	2.1		2.8		.8	
6	2.4			9.1		
8	1.4				4.6	
12	3.1					
Error Score of Normal Group	3.5	3.5	3.5	3.5	3.5	3.5

TABLE 50. TOTAL TIME CONSUMED IN THE RETENTION TEST

No. of Directed Trials in the Learning Period	Trial upon Which the Controlled Series is Introduced					
	1	3	5	7	9	11
2	28.0	21.0	19.9	21.9	31.4	22.0
4	24.4		17.6		18.8	
6	19.7			27.7		
8	21.0				31.1	
12	18.6					
Time Score of Normal Group	26.1	26.1	26.1	26.1	26.1	26.1

Among the groups in which the period of controlled learning began before the ninth trial, the number of errors accumulated in the test for retention tends to vary directly as the amount of guidance administered. The time consumed in the retention test by the groups which were guided early in the learning period tends to vary, on the contrary, inversely as the number of directed trials.

The relation between the effect of guidance upon learning and its effect upon retention is suggested by the correlations in Tables 51 and 52. The influence of two guided trials upon the number of errors accumulated in the learning period tends, in a general way,

TABLE 51. CORRELATIONS BETWEEN THE RANK OF INDIVIDUALS IN TERMS OF ERRORS MADE IN THE LEARNING WITH THE RANK IN TERMS OF ERRORS MADE IN THE RETENTION TEST[1]

No. of Guided Trials in the Learning Period	Trial upon Which the Guided Series is Introduced					
	1	3	5	7	9	11
2	−.37	−.14	+.31	−.39	−.50	−.01
4	+.40		+.25		+.48	
6	+.69			+.66		
8	+.71				−.21	
12	+.60					
Correlation in Case of Normal Group	+.15					

[1] All correlations reported in this monograph are based upon Spearman's formula:

$$\rho = 1 - \frac{6 \Sigma D^2}{N (N^2 - 1)}$$

to be the reverse of its influence upon the number of errors made in the retention test. The correlation between the quantities just indicated are negative and, though small, are rather consistently larger than the correlation between the same quantities in the normal group. In the case of the groups controlled for a period extending over more than two trials, the correlation between the number of errors made in the learning period and that made in the retention test is, as a rule, positive. As the amount of initial guidance is increased, the size of the correlation between the quantities in question increases.

In the case of the groups guided at an early stage of the learning the correlation between the time required for attaining a mastery of the problem and the time consumed in the retention test is positive and decreases in size as the length of the period of control is extended. Control, on the other hand, introduced upon the ninth trial or beyond, produces a negative correlation between the learning time and the time required in the retention test. Guidance in an intermediate position and not too limited in amount gives rise to a positive correlation between the two quantities under discussion.

TABLE 52. CORRELATION BETWEEN THE RANK OF INDIVIDUALS IN TERMS OF THE TIME CONSUMED IN THE LEARNING PERIOD WITH THE RANK IN TERMS OF THE TIME REQUIRED IN THE RETENTION TEST

No. of Directed Trials in the Learning Period	Trial upon Which the Guided Series is Introduced					
	1	3	5	7	9	11
2	+.59	−.58	+.58	−.40	−.29	−.23
4	+.22		+.32		−.36	
6	+.56			+.76		
8	+.48				−.23	
12	+.25					
Correlation in Case of Normal Group	+.13					

The correlation between the trial scores of the various groups and the error or time scores in the retention test do not deviate sufficiently from the normal nor exhibit sufficient regularity to justify any generalizations.

The mechanism by which control influences the retention of the maze habit is not entirely obvious. Several possible hypotheses in regard to this mechanism suggest themselves; but they are largely *a priori* in character and are offered only for what they are worth. In so far as the control prevents the formation of false habits, it should react favorably upon retention, for as the maze habit disintegrates and the organized proper response is no longer powerfully dominant, it is less probable that false reactions will occur in the test for retention, if they have never been experienced, than if the subject has frequently indulged in them. This error-preventing capacity of the control is greatest when the period of guidance occurs in the early stage of the learning, because it is in this stage that elaborate explorations prevail. Hence, one would expect guidance in the early trials to act most favorably upon retention. This our results indicate to be the case.

The hypothesis just advanced may, furthermore, account in part for the rather consistently positive correlations between the error scores for the learning period of the groups given initial guidance, and their error scores in the retention tests.

Control not only operates to prevent the formation of some improper habits, but it may establish a dependence upon false cues. To the extent to which guidance does result in the formation of two modes of response to many elements of the maze situation, and to the extent that these are conflicting, in part, at least, it is probable that control may have a deleterious action. If the habit has disintegrated far enough to weaken or destroy the dominance of the organized response not dependent upon the controlling device for cues, or the dominance of a concept of the relations of the various parts of the maze, a conflict of tendencies may result with a consequent increase in the error score of the retention test. Such a mode of functioning on the part of the control may account for the direct relation between the number of errors accumulated in the test for retention and the amount of guidance given in the learning period, as well as the detrimental effect upon retention of the directed runs introduced in the later stages of the learning.

The favorable influence of the longer period of control upon the time consumed in the retention test may be the result of a general speed set determined early in the period in which the habit is being acquired, by the simplicity of the task of mastering the cul-de-sac-less maze and the consequent confidence in ability to succeed.

V

THE INFLUENCE OF GUIDED LEARNING UPON THE ADAPTABILITY OF THE LEARNED REACTION

The adaptability of the reaction established with the aid of guidance was tested by having each subject trace the maze under a series of nine distracting conditions, forty-eight hours after he had mastered the problem. The distractions employed were: a shifting of the position of the maze through 90, 180 and 270 degrees, respectively; the silent recitation of the first stanza of "Mary had a little lamb"; reading aloud from a scientific text; drawing triangles with the left hand; tracing the maze with the left hand; traversing it from goal to entrance; and lastly, while tracing the maze with the left hand, drawing triangles with the right. The distractions were given in the indicated order. One trial only under each of the conditions was allowed. In those tests characterized by a modification in the position of the maze, the subject had no knowledge of the alteration.

The results of these tests are given in Tables 53 to 61. Both error and time records were taken, but since both exhibit the same tendencies, only the results based upon the error records are presented in the tables.

An inspection of the data reveals the fact that guidance sometimes increases and sometimes decreases the adaptability of the maze habit. The nature and degree of the influence of control is apparently a function of three interrelated conditions:

(1) *Amount of guidance*: In the test, for example, in which the maze is traversed with the right hand while the left is engaged in drawing triangles, the effect of initial guidance is invariably deleterious and the degree of detriment varies directly with the amount of control given.

As the period of guidance introduced upon the ninth run is extended from two to eight trials, the effect upon the adaptability of

the learned reaction to the 180 degree shift in the position of the maze becomes increasingly unfavorable.

Various amounts of initial guidance have a similar influence upon the adaptability of the reaction to the conditions of the tests in which the maze is traversed while the subject silently recites a jingle, or while he reads aloud, as well as that in which the position of the maze is shifted 90 degrees. The effect of the initial two trials is somewhat deleterious; four trials are distinctly favorable; while as the number of guided trials is extended from four to twelve, the influence becomes increasingly less favorable or more unfavorable.

These illustrations serve merely to demonstrate that the adaptability of the maze reaction to altered conditions is a function of the amount of guidance given in the learning period. The particular relations that obtain, however, between the amount of control and its effect upon the adaptability of the habit is conditioned by the position in the learning at which the given amount is interpolated, as well as the situation to which the habit must be adjusted. Four guided trials, for example, in the initial position increase above the normal the errors made in the test in which the maze is shifted 180 degrees, whereas they act to reduce the number of errors accumulated in the test characterized by silent recitation or reading aloud.

(2) *Position of guidance*: The adaptability of the reaction in the case of the groups controlled for four trials varies inversely, in seven of the tests, as the distance of the period of guidance from the initial trial. Under most of the other conditions presented by the tests, the influence of the position of the guided learning is less regular in its manifestations.

(3) *Nature of the problem*: There are some problems to which the reaction mastered with the aid of guidance is almost invariably adapted with more difficulty than that learned without guidance; other problems in which the reverse is true. The test in which the maze is traversed from the goal back to the entrance, as well as that in which one hand draws triangles while the other traces the maze, are examples of the former type. The test characterized by silent recitation or guiding the stylus with the left hand are exam-

ples of the latter type. The general characteristics of the two types of problem are not apparent. In fact, any functional classification of the problems that can be made must be so elastic it loses all significance.

It has, doubtless, occurred to the reader that probably some of the problems do not test the adaptability of the reaction at all, but rather the stability of the habit under distraction. The tasks which one would set apart on *a priori* grounds as tests of the stability of the habit are those in which the subject traverses the maze while silently reciting a jingle, while reading aloud, or while his left hand is engaged in drawing triangles. If these problems actually test the stability of the reaction, one would be justified in expecting guidance to influence the performance of the tasks in a manner similar to that in which it influenced performance in the retention test. The results of these three tests do not, however, exhibit any higher or more consistent correlations with the results of the retention test than are manifested by some of the other more distinctly adaptive problems. The correlation, furthermore, of the results of the three tests with the results in the learning period do not vary in the same way with the manner in which guidance is employed, as do the correlations between the results of the learning and retention tests. Hence, a classification of the problems on the basis of the degree to which they test stability or adaptability seems unwarranted.

The great complexity of the conditions resulting from the interaction of the three dependent variables—the nature of the problem, the amount of guidance and its position—renders impossible, at present, the prediction of the effect of any single factor, as well as any intelligent explanation of the results.

TABLE 53. SCORES REPRESENTING THE INFLUENCE OF GUIDANCE UPON THE NUMBER OF ERRORS MADE IN THE DISTRACTION TEST CHARACTERIZED BY A ROTATION OF THE POSITION OF THE MAZE THROUGH 90 DEGREES

No. of Directed Trials in the Learning Period	Trial upon Which the Controlled Series is Introduced					
	1	3	5	7	9	11
2	28.1	51.8	93.9	94.7	36.1	59.3
4	13.2		41.3		47.3	
6	19.7			43.0		
8	28.0				26.5	
12	84.7					
Error Score of Normal Group	22.9	22.9	22.9	22.9	22.9	22.9

TABLE 54. SCORES REPRESENTING THE INFLUENCE OF GUIDANCE UPON THE NUMBER OF ERRORS MADE IN THE DISTRACTION TEST CHARACTERIZED BY A ROTATION OF THE POSITION OF THE MAZE THROUGH 180 DEGREES

No. of Directed Trials in the Learning Period	Trial upon Which the Guided Series is Introduced					
	1	3	5	7	9	11
2	32.8	16.2	11.1	15.5	20.5	27.8
4	11.3		15.0		25.4	
6	19.5			7.5		
8	12.8				30.0	
12	136.6					
Error Score of Normal Group	18.0	18.0	18.0	18.0	18.0	18.0

TABLE 55. SCORES REPRESENTING THE INFLUENCE OF GUIDANCE UPON THE NUMBER OF ERRORS MADE IN THE DISTRACTION TEST CHARACTERIZED BY A ROTATION OF THE POSITION OF THE MAZE THROUGH 270 DEGREES

No. of Directed Trials in the Learning Period	Trial upon Which the Guided Series is Introduced					
	1	3	5	7	9	11
2	14.0	21.9	35.9	19.9	4.2	5.9
4	12.8		18.9		96.4	
6	7.3			15.4		
8	10.9				18.1	
12	44.8					
Error Score of Normal Group	12.8	12.8	12.8	12.8	12.8	12.8

TABLE 56. SCORES REPRESENTING THE INFLUENCE OF GUIDANCE UPON THE NUMBER OF ERRORS MADE IN THE DISTRACTION TEST CHARACTERIZED BY SILENT RECITATION

No. of Directed Trials in the Learning Period	Trial upon Which the Guided Series is Introduced					
	1	3	5	7	9	11
2	7.5	1.6	1.8	7.1	1.2	1.6
4	2.2		7.2		38.4	
6	3.2			2.2		
8	5.7				8.1	
12	34.4					
Error Score of Normal Group	3.9	3.9	3.9	3.9	3.9	3.9

TABLE 57. SCORES REPRESENTING THE INFLUENCE OF GUIDANCE UPON THE NUMBER OF ERRORS MADE IN THE DISTRACTION TEST CHARACTERIZED BY READING ALOUD

No. of Directed Trials in the Learning Period	Trial upon Which the Guided Series is Introduced					
	1	3	5	7	9	11
2	9.7	5.4	1.9	3.7	6.4	4.7
4	1.0		8.8		11.6	
6	5.1			9.8		
8	9.8				1.2	
12	13.3					
Error Score of Normal Group	1.9	1.9	1.9	1.9	1.9	1.9

TABLE 58. SCORES REPRESENTING THE INFLUENCE OF GUIDANCE UPON THE NUMBER OF ERRORS MADE IN THE DISTRACTION TEST CHARACTERIZED BY TRAVERSING THE MAZE FROM THE GOAL BACK TO THE BEGINNING

No. of Directed Trials in the Learning Period	Trial upon Which the Guided Series is Introduced					
	1	3	5	7	9	11
2	12.6	11.7	8.6	10.0	20.7	7.9
4	15.1		54.8		70.0	
6	12.0			4.4		
8	10.3				11.1	
12	10.2					
Error Score of Normal Group	7.1	7.1	7.1	7.1	7.1	7.1

TABLE 59. SCORES REPRESENTING THE INFLUENCE OF GUIDANCE UPON THE NUMBER OF ERRORS MADE IN THE DISTRACTION TEST CHARACTERIZED BY THE TRAVERSING OF THE MAZE WITH THE LEFT HAND

No. of Directed Trials in the Learning Period	Trial upon Which the Guided Series is Introduced					
	1	3	5	7	9	11
2	7.8	11.7	5.1	4.2	2.4	14.4
4	4.8		3.3		32.0	
6	7.5			2.1		
8	3.9				4.7	
12	14.4					
Error Score of Normal Group	5.3	5.3	5.3	5.3	5.3	5.3

TABLE 60. SCORE REPRESENTING THE INFLUENCE OF GUIDANCE UPON THE NUMBER OF ERRORS MADE IN THE DISTRACTION TEST CHARACTERIZED BY DRAWING TRIANGLES WITH THE LEFT HAND

No. of Directed Trials in the Learning Period	Trial upon Which the Guided Series is Introduced					
	1	3	5	7	9	11
2	12.7	14.2	5.3	9.6	14.3	8.2
4	23.1		23.6		67.8	
6	26.5			9.7		
8	41.3				33.1	
12	42.7					
Error Score of Normal Group	5.3	5.3	5.3	5.3	5.3	5.3

TABLE 61. SCORES REPRESENTING THE INFLUENCE OF GUIDANCE UPON THE NUMBER OF ERRORS MADE IN THE DISTRACTION TEST CHARACTERIZED BY DRAWING TRIANGLES WITH THE RIGHT HAND, WHILE THE LEFT HAND TRAVERSES THE MAZE

No. of Directed Trials in the Learning Period	Trial upon Which the Guided Series is Introduced					
	1	3	5	7	9	11
2	65.6	19.3	40.8	8.7	11.3	26.4
4	18.3		40.4		13.6	
6	34.9			4.4		
8	24.3				10.9	
12	20.7					
Error Score of Normal Group	9.6	9.6	9.6	9.6	9.6	9.6

VI

GENERAL SUMMARY

The discussion of the present chapter contains no new contribution to the material of the investigation. It presents briefly the general results of the study and the concepts which have been of value in the systematization of the facts. The hypotheses are submitted with no claim for their completeness as explanatory principles for the phenomena described, nor for their finality.

I. Influence of Control upon Learning

A. Factors Influential in Determining the Effect of Control upon Learning.

1. *Type of problem*: The present investigation, considered in conjunction with that reported by Carr and Koch,[1] reveals that the effectiveness of guidance is a function of the type of problem in which it is employed. Control in the alternation problem was deleterious in its effects, generally speaking, although there were apparently cases of great individual benefit. In the maze problem, on the contrary, the influence of control, in the case of the rats, is very beneficial. The two problems differ, in that the mastery of the maze involves primarily the elimination of excessive movements, whereas in the alternation problem, the acquisition of a type of response quite foreign to the animal constitutes the burden of the task.

2. *Species differences*: The results of the two experiments in which men and animals served as subjects diverge widely. Whether this divergence is dependent wholly upon species differences, upon the distribution of the effort, or upon other uncontrolled factors in the situations, it is not our privilege to say. We have merely the fact to offer that the control was very efficacious under the conditions maintained in the experiment conducted upon rats;

[1] *Op. cit.*

less efficacious, and at times even detrimental, in the experiment upon human subjects.

3. *Position of the control*: In the case of the animals, the degree of benefit derived from control administered somewhere within the first sixteen trials, varies inversely as the distance of the period of guidance from the beginning of the learning. The efficacy of the control, in the case of the human subjects, on the other hand, tends to vary directly as the distance (within limits) of the series of guided runs from the initial trial.

4. *Amount of control*: The efficacy of a given amount of guidance, according to our results, is a function of the period in the learning process at which the directed runs are interpolated. The relative influence of various amounts of guidance, furthermore, is not the same in the experiments conducted upon human and animal subjects. Hence, no broad generalization can be made concerning the optimum number of directed trials. It is worthy of note, however, that the relation between the amount and the efficacy of the control is no simple straight line relation. The modes of functioning of the control are many and often antagonistic. Little and much guidance in a given position, for instance, may be very effective, and effective in like degree, whereas a medium amount is of limited value. For another position, there may be an optimum amount of control which, if increased or decreased, causes a diminution in the efficacy of the guided effort.

B. Possible Modes in Which the Control may Function.

1. The closing of the blind alleys in the initial stage of the learning prevents the formation of habits of entering cul-de-sacs at a time when, under normal conditions, these habits are most readily acquired. The benefit derived from this particular mode of functioning on the part of the control is, probably, greatest in the very early trials, when the reaction to the maze situation is most diffuse, and is much reduced as soon as the reaction loses its rambling character. It is possible that the prevention of errors accounts in large measure for the great efficacy of initial guidance in the case of the rats whose learning proceeds, presumably, on a sensori-motor level. It may not be so efficacious in its influence

upon the human subjects whose learning is conceptual, in part at least. Learning what not to do may be of quite as much value to them as learning what to do.

2. In the very early trials, when the maze path is unfamiliar and retracings abundant, cul-de-sacs may act as barriers and prevent returns over any great part of the path. Consequently, one would expect the blocking of the blind alleys in the initial stage of the learning to favor long retracings and a resultant high error score. Such is the case with the animals; but the human subjects, quite contrarily, make fewer return errors in the first four trials when guided than when uncontrolled.

The turns in the true path of the small stylus maze prevent long returns in the very early stages of the learning. The simplification of the maze pattern, through the closing off of the blind alleys, also tends to decrease the retracings. Hence, in the early runs, the guided groups of human subjects make fewer errors than does the unguided group. As soon, however, as familiarity with the pathway is attained and the turns no longer act as barriers, a temporary accentuation of the retracing habit occurs, just as it did in the case of the animals in the early trials.

In the later stages of the learning, when the tendency to retrace is not very prominent, except as it is prompted by entrances into the cul-de-sacs, we should expect the prevention of cul-de-sac errors to greatly reduce the number of return errors made. This is probably the explanation of the reduction in the number of retracings which characterizes the later trials of the long periods of either initial or interpolated control.

The increase in the return errors accumulated in the initial trials of a period of interpolated guidance can be accounted for in terms of conflict and confusion. The introduction of the controlling device alters cues—especially if the guidance is interpolated later in the learning period—upon which the subject has come to depend, and thus temporarily disrupts the reaction.

3. The simplification of the maze pattern, particularly in the initial stages of the learning, may react upon the attitude of the subject toward the problem. Though we have no reason to doubt the influence of attitudinal factors in the learning of the animals,

we can speculate with confidence only in regard to their reaction upon the human subjects. The following are a few of the numerous possible ways in which the control may influence learning through the general set it provokes. The relative simplicity of the task of tracing the cul-de-sac-less maze, for example, may establish confidence on the part of the subject in his ability to master the problem, which in turn may increase his interest and serve as a goal to augment his effort. It is, on the other hand, not improbable that confidence will lead to carelessness or non-plasticity in the post-control period. Confidence established in the period of control may, moreover, act only to accentuate the discouragement which often attends the discovery of the cul-de-sacs in the post-control period.

It is not our intention to make a complete catalogue of the particular phase of the control's influence conditioned by the set it excites. Concerning the method, furthermore, whereby attitude influences learning, as well as the degree to which the attitude is conditioned by the manner in which the control is employed, we have no constructive suggestions to offer. We wish merely to suggest the factor as one that must be reckoned with in a complete description of the effect of guidance upon learning.

4. The control, to the extent to which it simplifies the maze pattern, may facilitate the formation, on the part of the human subject, of an accurate concept of the positional relations of the various parts of the true path. This mode of functioning is, presumably, influential in the case of initial and interpolated guidance and increases as the period of control is extended up to a certain point. It must be remembered, however, that the concept formed during the longer periods of initial guidance must undergo considerable remodelling when the subject is brought in contact with the cul-de-sacs in the post-control period. If, however, the control is interpolated later in the learning, it may facilitate the formation of a concept which includes not only the notion of what is the true path, but what is the false. This contrasting of the true path with the blind alleys through the aid of properly interpolated guidance may be one of the reasons why, in the case of the human

subjects, the efficacy of the control varies, in general, directly as the distance of the period of control from the initial trial.

5. Guidance, whether initial or interpolated, may act to facilitate the substitution of proper conceptual as well as sensory stimuli for releasing the desired responses. A human subject, for instance, may readily learn that catching his stylus in the notches in the wall produced by the guiding device, is not necessary and that the desired forward progress is made if he follows closely the opposite wall or runs the stylus swiftly down the path, until a certain turn is reached. The elimination of the habit of entering a cul-de-sac is much more difficult than making the substitution just described. The cul-de-sac may not be recognized as such for a long time. Even if the character of the blind alley is known, it is frequently difficult to overcome the tendency to make a slight excursion into the mouth of the alley before progressing forward. The process of overcoming the impulse to enter the cul-de-sac is often in its very last stages similar to the process of releasing oneself from dependence upon the notch as a cue for proceeding forward.

This facilitation of the formation of the proper reaction to a substituted stimulus which is not conditioned by the controlling device is a factor which, presumably, increases as the amount of control is increased. One would expect it to be operative in the case of both human and animal subjects.

6. Interpolated guidance may call attention to cul-de-sacs which were not, previous to the period of control, recognized as such. It is no uncommon occurrence for a human subject to enter a blind alley regularly for a long time without being aware of his uneconomical procedure. Control, though limited in amount, leads to the ready elimination of such an error.

7. The alteration of cues attendant upon the introduction and removal of the controlling device may be very distracting. If the cues have been thoroughly integrated into the subject's action system, the alteration of them may entice him into cul-de-sacs and cause much vain wandering. Short periods of initial guidance and control interpolated early in the learning period, however, do not have so disturbing a subsequent influence.

The alteration of cues necessitates, in the case of the human sub-

ject, a reorganization of his concept of the maze, as well as a reorganization of simple kinaesthetic- or tactual-motor habits. The elimination, for example, of landmarks such as the notches in the wall (as the entrances to the blocked alleys are known to the subjects) may disrupt the whole sequence of reactions, and cause elaborate analyses of the difficulty. The subject may instigate a systematic search for the lost cues which are never to be recovered. Long wanderings may occur which afford opportunity for the formation of many undesirable habits. Such a type of response to the modifications in the situation one might expect to occur, when the period of control has been rather extended and the cues from the guiding device explicitly recognized.

8. Control, if considerable in amount, and especially if interpolated rather late in the learning, may result in the formation of two types of reaction, of about equal strength, to a particular phase of the situation. A disrupting conflict of habits may be the consequence. One would expect this effect of control to be greater in the case of the animal than in the case of the human subjects.

9. The simplification of the task during the period of control often results, if the number of guided trials has been large, in the establishment of a rather high speed set which prevails throughout the rest of the learning.

2. Influence of Control upon Retention

A. Factors Influential in Determining the Effect of Control upon Retention.

1. *Position of the guided effort*: Control introduced early in the learning period (within the first six trials) is an aid to retention, whereas that occurring in the latter part of the first sixteen runs is unfavorable in its influence. The degree to which an accurate response to the maze situation is retained varies, generally speaking, inversely as the distance from the initial trial in the learning period at which the controlled runs are interpolated. The reader should not, however, be unmindful of the fact that retention was measured by the number of errors made and the time consumed in a single tracing of the maze forty-eight hours after a mastery of the problem had been attained. A different mode of

measurement—that of relearning, for instance—or a consideration of the results at a different stage of the disintegration of the habit might not reveal the existence of the same relations between the relative degree to which the maze habit is retained by the various guided groups.

2. *Amount of guidance*: Barring from consideration the cases of guidance introduced rather late in the learning period, we observe that the accuracy with which the maze habit functions after a forty-eight-hour interval of rest varies inversely as the amount of control given, whereas the speed with which the habit runs itself off tends to vary directly as the number of directed trials employed in the learning. No consistent relation is apparent between the degree of retention, as measured either in terms of errors or time, or the number of guided runs, when these are interpolated rather late in the learning period.

B. The Relation of the Influence of Guidance upon Learning and Retention.

The correlation between the influence of guidance on learning and retention is, as a rule, rather small. It may be positive or negative, depending on the number and position of the guided trials. A small amount of interpolated guidance usually results in a negative correlation. Initial guidance, on the other hand, generally produces a positive correlation. The size of the correlation between the error scores of the learning period and retention test increases as the amount of initial guidance is increased, whereas the correlation between the time consumed in the learning and that required in the retention test decreases as the period of initial guidance is extended.

C. Possible Modes in Which Controlled Learning may Influence Retention.

1. Control in the learning period may act to prevent contact with certain error situations. The reaction of this mode of functioning upon the retention of the proper habit would probably be favorable. The usual false reactions, whose formation in the learning period the control prevented, are not so likely to occur

when the habit functions after a lapse of time, as they would had the subject frequently indulged in them and eliminated them with effort. This reaction of controlled learning upon retention one would expect to find most marked in those groups of subjects whose period of guidance occurred when the opportunities for the prevention of false reactions were most abundant; namely, in the early trials of the learning period.

2. Controlled learning may lead to the formation of conflicting habits in response to certain elements of the maze situation. The proper response must, to be sure, attain a slight dominance in the learning period; but after the habit has had occasion to disintegrate somewhat, this dominance may be destroyed and the conflict renewed with the consequent appearance in the retention test of a large number of errors. Such a mode of reaction upon retention would be most prominent when the period of controlled learning has been rather extended or has occurred late in the acquisition of the maze habit.

3. Influence of Control upon the Adaptability of the Habit

The adaptability of the maze habit formed with the aid of guidance is conditioned by three interrelated factors; namely, the amount of guidance given, the position in the learning period at which the control occurs, and the nature of the altered situation to which the habit must be adjusted. On the basis of our results no generally applicable statement can be made concerning the influence of any one single factor.